SNDT Women's University, Mumbai

Master of Science in Data Science (M.Sc.-DS.)

as per NEP-2020

Syllabus

(2023-24)

(Dr G. M. Magar)
(BOS-chairperson)

Programme	Master of Science in Data Science (M.Sc.-DS.)
Preamble	In pursuit of academic excellence and a comprehensive understanding of the rapidly evolving field of Data Science, the Master of Science in Data Science program is designed to equip students with a profound knowledge base and practical skills. This program integrates a diverse range of courses that blend theoretical foundations with hands-on experiences, ensuring our graduates are well-prepared for the dynamic challenges of the data-driven era.
Programme Outcomes (POs)	Upon successful completion of the Master of Science in Data Science program, graduates will demonstrate: • **Proficiency in Data Analysis:** Graduates will possess the skills to analyze complex datasets, employing statistical and machine learning techniques to derive meaningful insights and make informed decisions. • **Competence in Programming and Software Development:** Graduates will be proficient in programming languages such as Python and R, capable of developing and implementing data science solutions effectively. • **Mastery of Big Data Technologies:** Graduates will have a comprehensive understanding of big data technologies and tools, enabling them to handle and process large volumes of data efficiently. • **Application of Machine Learning and Deep Learning:** Graduates will be able to apply machine learning and deep learning techniques to solve real-world problems, including tasks such as classification, regression, clustering, and natural language processing. • **Business Intelligence and Decision Support:** Graduates will be equipped with the skills to leverage data for strategic decision-making, bridging the gap between data science and business intelligence. • **Ethical and Responsible Data Practices:** Graduates will demonstrate an understanding of ethical considerations in data science, adhering to responsible data practices and respecting privacy and confidentiality. • **Effective Communication and Visualization**: Graduates will be adept at communicating complex technical concepts to diverse audiences and utilizing data visualization tools to present findings in a clear and compelling manner. • **Research and Innovation in Data Science:** Graduates will have the ability to engage in research

(Dean, Mages)
(BOS-chairperson)

	activities, contributing to the advancement of knowledge in the field of data science, and fostering innovation in data-driven solutions. • **Specialized Knowledge in Chosen Elective Areas:** Graduates will exhibit specialized knowledge in elective areas chosen during the program, such as cyber security, artificial intelligence, database systems, or other relevant domains. • **Practical Experience through Internships and Projects:** Graduates will have practical experience gained through internships, on-the-job training (OJT), and research projects, enhancing their ability to apply theoretical knowledge in real-world settings. • **Continuous Learning and Adaptability:** Graduates will demonstrate a commitment to continuous learning, staying abreast of emerging technologies and industry trends in the rapidly evolving field of data science • **Collaboration and Teamwork:** Graduates will be effective collaborators, able to work seamlessly within interdisciplinary teams to address complex data science challenges.
Programme Specific Outcomes (PSOs)	Programme Specific Outcomes (PSOs) for an MSC in Data Science specify the particular skills, knowledge, and abilities that students are expected to gain upon completion of the program. • **Advanced Data Analysis Proficiency**- Graduates will be proficient in employing advanced statistical and machine learning techniques for data analysis, extracting meaningful insights and making data-driven decisions in diverse domains. • **Programming and Software Development Skills**- Graduates will demonstrate advanced programming skills, with the ability to develop and implement data science solutions using languages such as Python and R. • **Expertise in Big Data Technologies** -Graduates will exhibit expertise in utilizing and managing big data technologies and tools, demonstrating proficiency in handling and processing large-scale datasets. • **Application of Machine Learning and Deep Learning** -Graduates will showcase expertise in applying machine learning and deep learning techniques to solve complex problems, including tasks such as classification, regression, clustering, and natural language processing. • **Business Intelligence and Strategic Decision Support** -Graduates will possess the skills to integrate data science insights with business intelligence, supporting strategic decision-making processes within organizations.

	• **Ethical and Responsible Data Practices**- Graduates will adhere to ethical considerations in data science, practicing responsible data handling, and demonstrating an understanding of privacy and confidentiality issues. • **Effective Communication and Data Visualization**- Graduates will effectively communicate complex technical concepts and present data-driven findings using visualization tools, catering to diverse audiences. • **Research and Innovation in Data Science** - Graduates will engage in research activities, contributing to the advancement of knowledge in data science and fostering innovation in data-driven solutions. • **Specialized Knowledge in Elective Areas** - Graduates will apply specialized knowledge gained in elective areas, such as cybersecurity, artificial intelligence, database systems, or other chosen domains, to address specific data science challenges. • **Practical Experience through Internships and Projects -**Graduates will demonstrate practical experience gained through internships, on-the-job training (OJT), and research projects, showcasing their ability to apply theoretical knowledge in practical scenarios. • **Continuous Learning and Adaptability**- Graduates will exhibit a commitment to continuous learning, staying updated on emerging technologies and industry trends in the rapidly evolving field of data science. • **Collaboration and Teamwork Skills** -Graduates will demonstrate effective collaboration and teamwork skills, working seamlessly within interdisciplinary teams to address complex data science challenges.
Eligibility Criteria for Programme	A woman Graduate in any B.Sc. (Physics), B.Sc. (Mathematics), B.Sc. (Electronics), B.Sc. (Information Technology), B.Sc. (Computer Science), B.Sc. (IT) or BCA or any engineering graduate in allied subject from the recognized university with aggregate marks not less than 50% for Open Category and 45% Reserved Category.
Intake	60
Duration	4 semesters (2 years)

Master of Science in Data Science(M.Sc.-DS.)

Year -I

Code	Subjects	Type of Course	Credits	Marks	Int.	Ext.
	`					
115611	Computer Oriented Statistical Techniques-I	Major (Core) Theory	4	100	50	50
115612	Data Structure and Analysis of Algorithms	Major(Core) Theory	4	100	50	50
115613	Python Programming	Major(Core) Theory	2	50	0	50
115624	Computer Oriented Statistical Techniques– Lab(Using R)	Major (Core) Practical	2	50	25	25
115625	Data Base Management Systems-Lab	Major (Core) Practical	2	50	25	25
	Elective-I	Major (Elective) Theory	4	100	50	50
135611	Research Methodology	Minor Stream (RM) Theory	4	100	50	50
			22	550	250	300
	Semester-II					
Code	**Subjects**	**Type of Course**	**Credit**	**Marks**	**Int.**	**Ext.**
215611	Data Mining with Analytics	Major (Core) Theory	4	100	50	50
215612	Applied Artificial Intelligence	Major (Core) Theory	4	100	50	50
215613	Introduction to Data Science	Major (Core) Theory	2	50	50	0
215624	Data Mining with Analytics --Lab	Major (Core) Practical	2	50	25	25
215625	Applied Artificial Intelligence–Lab	Major (Core) Practical	2	50	25	25
	Elective-II-	Major (Elective) Theory	4	100	50	50
255631	RP/Internship	RP/Internship	4	100	50	50
			22	550	300	250

Exit option(44 credits):
Post Graduate Diploma in Data Science

Year -II

Code	Subjects	Type of Course	Credit	Marks	Int.	Ext.
	Semester-III					
315611	Big Data Analytics	Major(Core) Theory	4	100	50	50
315612	Machine Learning	Major(Core) Theory	4	100	50	50
315615	Business Intelligence	Major(Core) Theory	2	50	0	50
315623	Big Data Analytics-Lab	Major(Core) Practical	2	50	25	25
315624	Machine Learning-Lab	Major(Core) Practical	2	50	25	25
	Elective-III	Major(Elective) Theory	4	100	50	50
355631	RP/Internship	RP/Internship	4	100	50	50
			22	550	250	300
	Semester-IV					
415611	Deep Learning	Major (Core) Theory	4	100	50	50
415612	Natural Language Processing	Major (Core) Theory	4	100	50	50
415623	Deep Learning-Lab	Major (Core) Practical	2	50	25	25
415624	Natural Language Processing-Lab	Major (Core) Practical	2	50	25	25
	Elective-IV/MOOC/SWAYAM	Major (Elective) Theory	4	100	50	50
445641	OJT		6	150	100	50
			22	550	300	250

Code	Elective-I	Code	Elective-II
125611	1. Cyber Security	225611	1. Ethical Hacking
125612	2. Digital Image Processing	225612	2. Project Management
125613	3. Software Engineering	225613	3. Fuzzy Logic and Neural Network
125614	4. Artificial Intelligence	225614	4. Linear Algebra
125615	5. Database Systems for Data Science	225615	5. Inferential Statistics

Code	Elective-III	Code	Elective-IV
325611	1. Block chain	325611	1. Information Security
325612	2. GIS and Remote Sensing	325612	2. Cloud Computing
325613	3. Software Testing	325613	3. Robotic Process Automation
325614	4. Data Visualization	325614	4. Social network Analysis
325615	5. Data Governance	325615	5. Agile Methodology

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
115611	**COMPUTER ORIENTED STATISTICAL TECHNIQUES-I** **Major (Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Summation notation, and other essential mathematical notations used in statistical analysis. • Calculate and interpret averages, such as the arithmetic mean, weighted arithmetic mean, median, mode, and other measures of central tendency, for both raw and grouped data.		
Module 1	**MEASURES OF CENTRAL TENDENCY AND DISPERSION**		1
	LOs: Learners will be able to • Define and compute various measures of central tendency, including averages such as mean, median, and mode. • Compare and contrast the applications of mean, median, and mode in different types of datasets. • Define Dispersion or Variation. • Explore measures like Range, Mean Deviation, Semi-Interquartile Range, and Percentile Range. • Study the Standard Deviation and Variance. • Explore short methods for computing Standard Deviation. • Discuss the properties of the Standard Deviation. • Understand Charlie's Check and Sheppard's Correction for Variance. • Explore empirical relations between measures of dispersion. • Discuss Absolute and Relative Dispersion, Coefficient of Variation, Standardized Variable, and Standard Scores. • Examine software applications for computing Measures of Dispersion.	**Module Contents:** **The Mean, Median, Mode, and Other Measures of Central Tendency:** • Index, or Subscript, Notation, Summation Notation, Averages, or Measures of Central Tendency ,The Arithmetic Mean , The Weighted Arithmetic Mean ,Properties of the Arithmetic Mean, The Arithmetic Mean Computed from Grouped Data ,The Median ,The Mode, The Empirical Relation Between the Mean, Median, and Mode, The Geometric Mean G, The Harmonic Mean H ,The Relation Between the Arithmetic, Geometric, and Harmonic Means, The Root Mean Square, Quartiles, Deciles, and Percentiles, Software and Measures of Central Tendency. • The Standard Deviation and Other Measures of Dispersion: Dispersion, or Variation, The Range, The Mean Deviation, The Semi- Interquartile Range, The Percentile Range, The Standard Deviation, The Variance, Short Methods for Computing the Standard Deviation, Properties of the Standard Deviation. • Charlie's Check, Sheppard's Correction for Variance, Empirical Relations Between Measures of Dispersion, Absolute and Relative Dispersion; Coefficient of Variation, Standardized Variable; Standard Scores, Software and Measures of Dispersion.	

Module 2	ELEMENTARY PROBABILITY AND SAMPLING THEORY		1
	LOs: Learners will be able to • Discuss relations between moments and Charlie's Check, Sheppard's Corrections. • Study skewness and kurtosis, both for population and sample. • Explore software applications for computing skewness and kurtosis. • Define Probability and explore Conditional Probability. • Understand Independent and Dependent Events, Mutually Exclusive Events. • Discuss Probability Distributions and Mathematical Expectation. • Explore the relation between Population, Sample Mean, and Variance. • Introduce Combinatorial Analysis, Combinations, and Stirling's Approximation to n!. • Discuss the relation of Probability to Point Set Theory and Euler or Venn Diagrams.	**Module Contents:** • **Moments, Skewness, and Kurtosis**: Moments , Moments for Grouped Data ,Relations Between Moments , Computation of Moments for Grouped Data, Charlie's Check and Sheppard's Corrections, Moments in Dimensionless Form, Skewness, Kurtosis, Population Moments, Skewness, and Kurtosis, Software Computation of Skewness and Kurtosis. • **Elementary Probability Theory**: Definitions of Probability, Conditional Probability; Independent and Dependent Events, Mutually Exclusive Events, Probability Distributions, Mathematical Expectation, Relation Between Population, Sample Mean, and Variance, Combinatorial Analysis, Combinations, Stirling's Approximation to n!, Relation of Probability to Point Set Theory, Euler or Venn Diagrams and Probability. • **Elementary Sampling Theory**: Sampling Theory, Random Samples and Random Numbers, Sampling With and Without Replacement, Sampling Distributions, Sampling Distribution of Means, Sampling Distribution of Proportions, Sampling Distributions of Differences and Sums, Standard Errors, Software Demonstration of Elementary Sampling Theory.	
Module 3	**STATISTICAL ESTIMATION THEORY**		1
	LOs: Learners will be able to • Explore the Estimation of Parameters. • Understand Unbiased and Efficient Estimates. • Discuss Point Estimates and Interval Estimates along with their reliability. • Explore Confidence-Interval Estimates of Population Parameters and Probable Error.	**Module Contents:** • **Statistical Estimation Theory:** Estimation of Parameters, Unbiased Estimates, Efficient Estimates, Point Estimates and Interval Estimates; Their Reliability, Confidence-Interval Estimates of Population Parameters and Performance, Probable Error. • **Statistical Decision Theory:** Statistical Decisions, Statistical Hypotheses, Tests of Hypotheses and Significance, or Decision Rules, Type I and Type II Errors, Level of Significance, Tests	

		Involving Normal Distributions, Two-Tailed and One-Tailed Tests, Special Tests, Operating-Characteristic Curves; the Power of a Test, p-Values for Hypotheses Tests, Control Charts, Tests Involving Sample Differences, Tests Involving Binomial Distributions. • **Statistics in R:**mean, median, mode, Normal Distribution, Binomial Distribution, Frequency Distribution in R	
Module 4	**CORRELATION THEORY**		1
	LOs: Learners will be able to • Introduce the freehand method for curve fitting. • Discuss its applications and limitations. • Study the concept of the straight line in curve fitting. • Introduce the method of least squares for linear regression. • Understand the derivation of the least-squares line. • Explore nonlinear relationships in curve fitting. • Discuss the application of the least-squares method to parabolas. • Study linear correlation and its measures. • Discuss various measures of correlation. • Understand the derivation of least-squares regression lines. • Explore the concept of standard error of estimate.	**Module Contents:** **Curve Fitting and the Method of Least Squares:** • Relationship Between Variables, Curve Fitting, Equations of Approximating Curves, Freehand Method of Curve Fitting, The Straight Line, The Method of Least Squares, The Least-Squares Line, Nonlinear Relationships, The Least-Squares Parabola, Regression, Applications to Time Series, Problems Involving More Than Two Variables **Correlation Theory:** • Correlation and Regression, Linear Correlation, Measures of Correlation, The Least-Squares Regression Lines, Standard Error of Estimate, Explained and Unexplained Variation, Coefficient of Correlation, Remarks Concerning the Correlation Coefficient, Product-Moment Formula for the Linear Correlation Coefficient, Short Computational Formulas, Regression Lines and the Linear Correlation Coefficient, Correlation of Time Series, Correlation of Attributes, Sampling Theory of Correlation, Sampling Theory of Regression.	
Assignments/ Activities			
	• Define and explain Index or Subscript Notation and Summation Notation. Provide examples. • Discuss the concept of Averages or Measures of Central Tendency. • Explore the properties of the Arithmetic Mean and its computation from grouped data. • Explain the concepts of Median, Mode, Geometric Mean, Harmonic Mean, and their empirical relations. • Discuss the importance of Quartiles, Deciles, Percentiles, and provide an example.		

	• Define Dispersion or Variation. Discuss its importance. • Explore measures like Range, Mean Deviation, Semi-Interquartile Range, and Percentile Range. • Study the concepts of Standard Deviation and Variance. • Discuss short methods for computing the Standard Deviation. • Examine the properties of the Standard Deviation. • Explain Charlie's Check and Sheppard's Correction for Variance. • Explore empirical relations between Measures of Dispersion. • Discuss Absolute and Relative Dispersion, Coefficient of Variation, Standardized Variable, and Standard Scores. • Demonstrate the use of software in computing Measures of Dispersion.	

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Newbold, P., Carlson, W. L., & Thorne, B. (Year). "Statistics for Business and Economics." Publisher.

Johnson, R. A., & Wichern, D. W. (Year). "Applied Multivariate Statistical Analysis." Publisher.

Ruppert, D. (Year). "Statistics and Data Analysis for Financial Engineering." Publisher.

Agresti, A., & Finlay, B. (Year). "Statistical Methods for the Social Sciences." Publisher.

James, G., Witten, D., Hastie, T., & Tibshirani, R. (Year). "An Introduction to Statistical Learning." Publisher.

Wickham, H., & Grolemund, G. (Year). "R for Data Science." Publisher.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
115612	**DATA STRUCTURES AND ANALYSIS OF ALGORITHMS**		**4**
	Course Outcomes: **Learners will be able to:** • To analyses the asymptotic performance of algorithms. • To write the rigorous correctness proofs for algorithms. • To demonstrate a familiarity with major algorithms and data structures. • To apply important algorithmic design paradigms and methods of analysis. • To synthesize efficient algorithms in software design and development		
Module 1	**LINEAR DATA STRUCTURES**		1
	LOs: Learners will be able to • Define and explain the fundamental concepts of data structures, including arrays, stacks, queues, and linked lists. • Identify scenarios where each data structure is best suited for efficient data organization and manipulation. • Demonstrate a clear understanding of asymptotic notations, including Big-Oh, Omega, and Theta, and their application in analyzing algorithmic time and space complexities. • Apply asymptotic notations to evaluate and compare the efficiency of algorithms related to data structures.	**Module Contents:** • Introduction to Data Structures – Fundamental Elements – Asymptotic Notations: Big-Oh, Omega and Theta – Best, Worst and Average case Analysis: • Definition and an example – Arrays and its representations • Stacks and Queues – Linked lists – Singly Linked List – Doubly linked list – Linked list based implementation of Stacks and Queues. Evaluation of Expressions	
Module 2	**NON-LINEAR DATA STRUCTURES**		1
	LOs: Learners will be able to • Define the basic concepts of trees and their significance in data representation and manipulation. • Differentiate between trees and other data structures, emphasizing the hierarchical nature of tree structures. • Introduce binary trees and their applications in various domains. • Demonstrate proficiency in representing binary trees using both array and linked list structures.	**Module Contents:** • Trees: Introduction to Trees – Basic concepts – Binary Trees – Binary tree representations (Array and list) and Traversals Techniques (Preorder, Inorder, Postorder) • Succinct Data Structures: Overview – Level order representation of Binary Trees – Rank and Select – Sub trees. • Graphs: Definitions, Terminologies, Matrix and Adjacency List Representation Of Graphs, Elementary Graph operations, Traversal methods: Breadth First Search and Depth First Search.	
Module 3	**SEARCH TREE STRUCTURES AND PRIORITY QUEUES**		1
	LOs: These learning outcomes aim to • Define Binary Search Trees and their properties. • Implement and analyze fundamental	**Module Contents:** ● Binary Search Trees – AVL Trees – Splay Trees ● Fusion Data Structures:	

	operations on BSTs, including insertion, deletion, and search. • Explain the concept of AVL Trees and their self-balancing properties. • Implement rotations and algorithms to maintain the balance of AVL Trees.	Sketching- Approximating the sketch – Parallel comparison ● Desk etching – Application of Fusion Tree Structures – Priority Queues – Heaps implementations – Binary Heap	
Module 4	**SORTING , SEARCHING and INDEXING, DISJOINT SETS**		1
	LOs: Learners will be able to • Understand the basic concepts of sorting algorithms and their importance in data manipulation. • Implement and analyze the performance of fundamental sorting algorithms, including Bubble Sort, Insertion Sort, Selection Sort, Quick Sort, Shell Sort, Heap Sort, Merge Sort, and External Sorting.	**Module Contents:** • Sorting Algorithms: Basic concepts – Bubble Sort – Insertion Sort – Selection Sort – Quick Sort – Shell sort – Heap Sort – Merge Sort – External Sorting. Searching: Linear Search, Binary Search. • Indexing: Hashing – Hash Functions – Separate Chaining – Open Addressing: Linear Probing- Quadratic Probing- Double Hashing- Rehashing – Extendible Hashing. • Disjoint Sets: Basic data structure	
Assignments/ Activities			
	Test student's understanding of fundamental concepts of data structure and algorithm. • Research and present examples illustrating Big-Oh, Omega, and Theta notations. • Analyze and compare the time complexities of different algorithms using these notations. • Create and visualize binary trees using array and linked list representations. • Implement and demonstrate tree traversal techniques (Preorder, Inorder, Postorder). • Explore and implement Breadth First Search and Depth First Search algorithms for graph traversal. • Study and implement level order representation of binary trees. • Investigate and implement Rank and Select operations on succinct data structures. • Implement Binary Search Trees and AVL Trees. • Analyze and compare the performance of these tree structures. • Implement hash functions and explore different hashing techniques.		

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Pai, G. A. V. (2008). Data Structures and Algorithms: Concepts, Techniques, and Applications (1st ed.).

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Tremblay, J.-P., & Sorenson, P. G. (2007). An Introduction to Data Structures with Applications (2nd ed.). Tata McGraw-Hill.

Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2003). Introduction to Algorithms (2nd ed.). PHI.

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<table>
<tr><th>SN</th><th>Courses, Modules and Outcomes</th><th>Course Contents</th><th>Cr</th></tr>
<tr><td></td><td colspan="2">Semester I</td><td></td></tr>
<tr><td>115613</td><td colspan="2">PYTHON PROGRAMMING
Major (Core) Theory</td><td>2</td></tr>
<tr><td></td><td colspan="2">Course Outcomes:
Learners will be able to:

• To understand why Python is a useful scripting language for developers.
• To learn how to design and program Python applications.
• To learn how to use Python for Data Science and statistics
• To learn how to build and package Python modules for reusability.
• To learn how to design object-oriented programs with Python classes.
• To learn how to use class inheritance in Python for reusability.
• To learn how to use exception handling in Python applications for error handling.
• Identify the need for data science and solve basic problems using Python built-in data types and their methods</td><td></td></tr>
<tr><td>Module 1</td><td colspan="2">INTRODUCTION OF PYTHON PROGRAMMING WITH OOP, FILE AND EXCEPTION HANDLING</td><td>1</td></tr>
<tr><td></td><td>LOs: Learners will be able to

• Understand key features of Python.
• Demonstrate knowledge of identifiers, reserved words, and proper code indentation.
• Utilize built-in data types (Strings, Lists, Tuples, Dictionaries, Sets) and perform type conversions.
• Apply various operators for effective programming.
• Implement decision-making constructs and loops. Demonstrate control statements within loops.
• Design and use user-defined functions with various argument types. Create and utilize user-defined modules and understand their role.
• Perform file manipulations and utilize file and directory-related methods.
• Implement exception handling using try, except, and finally blocks.
• Understand OOP concepts, Implement inheritance, polymorphism, encapsulation, and use anonymous functions (lambda functions).</td><td>Module Contents:

Introduction to Python Programming–
Why Python? – Essential Python libraries – Python Introduction- Features, Identifiers, Reserved words, Indentation, Comments, Built-in Data types and their Methods: Strings, List, Tuples, Dictionary, Set – Type Conversion- Operators

Decision Making- Looping- Loop Control statement- Math and Random number functions

User defined functions – function arguments & its types User defined Modules and Packages in Python-

Files:
File manipulations, File and Directory related methods

Python Exception Handling.
OOPs Concepts –
Class and Objects, Constructors – Data hiding- Data Abstraction- Inheritance, Types of Inheritance, Polymorphism, Encapsulation, Anonymous Function.</td><td></td></tr>
</table>

Module 2	INTRODUCTION TO NUMPY AND MANIPULATE WITH PANDAS		1
	LOs: Learners will be able to • Understand the concept of arrays and vectorized computation in NumPy. • Create and manipulate NumPy ndarrays, including specifying data types. • Apply arithmetic operations efficiently using NumPy. • Perform basic indexing, slicing, and Boolean indexing on NumPy arrays. • Demonstrate the transposition of arrays. • Apply universal functions for fast element-wise array operations. • Utilize mathematical and statistical methods on NumPy arrays. Implement sorting, unique, and other set logic operations. • Understand pandas data structures, including Series and DataFrames. • Apply essential functionality such as dropping entries, indexing, selection, and filtering in pandas. • Demonstrate data manipulation techniques, including function application and mapping. • Read and write data in text format using pandas. • Understand and apply concepts of unique values, value counts, and membership in pandas DataFrames.	**Module Contents:** **NumPy Basics:** Arrays and Vectorized Computation- The NumPy ndarray- Creating ndarrays- Data Types for ndarrays- Arithmetic with NumPy **Arrays-** Basic Indexing and Slicing – Boolean Indexing- Transposing Arrays **Universal Functions**: Fast Element-Wise Array Functions- Mathematical and Statistical Methods-Sorting Unique and Other Set Logic. **Introduction to pandas Data Structures**: Series, Data Frame, Essential Functionality: Dropping Entries Indexing, Selection, and Filtering- Function Application and Mapping- Sorting and Ranking. **Summarizing and Computing Descriptive Statistics-** Unique Values, Value Counts, and Membership. Reading and Writing Data in Text Format.	
Assignments/ Activities			
	Test student's understanding of fundamental concepts: • Create Python scripts showcasing fundamental features, essential libraries, and manipulation of built-in data types. • Develop programs for file manipulations, demonstrating file and directory-related methods, and incorporating exception handling. • Implement OOP concepts including class, object, inheritance, polymorphism, encapsulation, and anonymous functions. • Write Python scripts utilizing NumPy for array operations and pandas for data manipulation, summarization, and descriptive statistics.		

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NumPy, and Ipython." O'Reilly, 2nd Edition.

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<table>
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<tr><td></td><td colspan="2">Semester I</td><td></td></tr>
<tr><td>115624</td><td colspan="2">COMPUTER ORIENTED STATISCAL TECHNIQUES-(USING R)LAB-PRACTICAL
Major (Core)</td><td>2</td></tr>
<tr><td></td><td colspan="2">Course Outcomes:
Learners will be able to:

• Execute basic commands in R and demonstrate proficiency in working with arrays, lists, and data frames.
• Create matrices in R and perform operations such as addition, inverse, transpose, and multiplication.
• Utilize R to execute statistical functions, including mean, median, mode, quartiles, range, interquartile range, and histogram creation.
• Import data from Excel/.CSV files into R and calculate standard deviation, variance, and covariance.
• Import data from Excel/.CSV files and draw skewness. Perform hypothetical testing on imported data.
• Import data from Excel/.CSV files and perform the Chi-squared test. Utilize R to perform binomial and normal distribution analysis on data. Perform linear regression analysis using R.
• Compute least squares means using R. Perform linear least square regression using R.</td><td></td></tr>
<tr><td>Module 1</td><td colspan="2">STATSTICAL ESTIMATION USING R</td><td>1</td></tr>
<tr><td></td><td>LOs: Learners will be able to

• Demonstrate proficiency in using R for executing basic commands. Create and manipulate arrays, lists, and data frames in R.

• Create matrices in R and perform fundamental operations such as addition, inverse, transpose, and multiplication.

• Execute statistical functions in R, including mean, median, mode, quartiles, range, interquartile range, and histogram creation.

• Import data from Excel/.CSV files into R and calculate standard deviation, variance, and covariance.

• Use R to import data from Excel/.CSV files and draw skewness.

• Apply R for performing hypothetical testing on imported data.</td><td>Module Contents:

• Using R execute the basic commands, array, list and frames
• Create a Matrix using R and Perform the operations addition, inverse, transpose and multiplication operations
• Using R Execute the statistical functions: mean, median, mode, quartiles, range, inter quartile range histogram
• Using R import the data from Excel / .CSV file and Calculate the standard deviation, variance, co-variance
• Using R import the data from Excel / .CSV file and draw the skewness
• Import the data from Excel / .CSV and perform the hypothetical testing</td><td></td></tr>
</table>

Module 2	ADVANCE STATISTICAL ANALYSIS USING R		1
	LOs: Learners will be able to • Import data from Excel/.CSV files into R for conducting the Chi-squared test. • Understand the application of the Chi-squared test for analyzing categorical data. • Utilize R to perform binomial distribution analysis on data. • Perform linear regression analysis using R. • Compute least squares means using R. • Apply R to compute linear least square regression. Understand the process of fitting a linear model to observed data using the least squares method.	**Module Contents:** • Import the data from Excel / .CSV and perform the Chi-squared Test • Using R perform the binomial and normal distribution on the data • Perform the Linear Regression using R • Compute the Least squares means using R • Compute the Linear Least Square Regression	
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	• Execute basic R commands, and manipulate arrays, lists, and frames. • Create and perform operations on matrices, including addition, inverse, transpose, and multiplication. • Utilize R for statistical functions like mean, median, mode, quartiles, range, interquartile range, and histogram. • Import data from Excel/.CSV files into R and calculate standard deviation, variance, and covariance. • Draw skewness for imported data. • Apply statistical concepts learned in R to real-world datasets. • Perform the Chi-squared test on imported data. Utilize R for binomial and normal distribution analysis. Implement linear regression in R and compute least squares means. • Gain practical experience in applying advanced statistical methods using R. Interpret and communicate findings from statistical analyses.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
115625	**Database Management system Lab: Practical** **Major (Core)**		**2**
	Course Outcomes: **Learners will be able to:** • Proficiently create and manage databases and tables using SQL • Demonstrate the ability to perform various Data Definition Language (DDL) operations and handle constraints on tables. • Execute CRUD operations and basic SQL statements for data manipulation. • Apply advanced querying techniques, including CASE statements, different types of joins, and Date/Time functions. • Install MongoDB and perform basic operations like database and collection creation. • Demonstrate proficiency in CRUD operations, aggregation functions, and index management in MongoDB. • Configure a MongoDB replica set, enabling replication and testing the process.		
Module 1	**OVERVIEW OF SQL**		1
	LOs: Learners will be able to • Proficiently create and manage structured databases and tables using SQL. • Demonstrate expertise in performing various Data Definition Language (DDL) operations and handling constraints on tables. • Master both basic and advanced SQL statements, including INSERT, UPDATE, DELETE operations, and basic data manipulation. • Gain proficiency in advanced querying techniques, such as CASE statements, different types of joins, and Date/Time functions, for effective data retrieval and analysis.	**Module Contents:** • Creating and Managing Structured Database and Tables A. Create Database B. Create Table C. Perform other DDL operations on table D. Handle different constraints on the table • SQL Statements I: A. Using INSERT, UPDATE, DELETE operations on tables B. Basic SQL Statements C. Restricting and sorting data D. Simple inline calculations E. Complex inline calculations • SQL Statements II: A. CASE Statement in SQL query B. Implementing different types of join C. Performing various Date/Time functions on SQL queries • Exploratory Data Analysis with SQL: A. Handling multiple tables simultaneously B. Analyzing changes over time in different tables C. Analytical reporting using SQL D. Create and manage view E. Create and manage CTE • Advanced Query Handling:	

		A. Using SET Operators B. Datetime Functions C. Enhancements to the GROUP BY Clause D. Advanced Subqueries • Create and handle any two Machine Learning Datasets using simple SQL	
Module 2	**INTRODUCTION TO MONGODB**		1
	LOs: Learners will be able to • Proficiently install MongoDB and perform basic operations, including database and collection creation • Demonstrate competence in using MongoDB shell commands for listing databases, collections, counting documents, and finding documents by ID. • Execute CRUD operations on data, gaining practical experience in data manipulation within MongoDB. • Manage indexes in MongoDB, including creating different indexes in a collection, searching/seeing indexes, and dropping indexes. • Gain proficiency in configuring and enabling replica sets in MongoDB. • Demonstrate the ability to add and remove MongoDB instances in replica sets and test the replication process, ensuring data redundancy and high availability.	**Module Contents:** • Installation of MongoDB • Create database and collection in MongoDB • Basic MongoDB shell handling commands: List database, List collections, Count documents, Find document by ID • Perform CRUD operations on data • Use different aggregation functions on data • Managing Indexes A. Create different indexes in collection B. Search/See indexes on collection C. Drop an index • Replica Set: A. Configure Replica Set B. Enable Replication in MongoDB C. Adding and Removing MongoDB instances in Replica Sets D. Testing the Replication Process	
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	• Create a database with specified attributes. Design and create tables with appropriate data types. Perform various DDL operations on the created tables. • Execute INSERT, UPDATE, DELETE operations on tables with sample data. Write basic SQL statements for data retrieval and manipulation. Create SQL queries with CASE statements, implement joins, and use Date/Time functions. • Handle multiple tables simultaneously in SQL for exploratory data analysis. Generate analytical reports using SQL queries. Utilize SET operators, datetime functions, and advanced subqueries for complex data retrieval. • Install MongoDB on a specified platform. Create a database and collection in MongoDB. Execute basic MongoDB shell commands for listing databases, collections, and counting documents.		

		• Perform CRUD operations on MongoDB data. Use different aggregation functions on MongoDB collections. Create and manage indexes in MongoDB collections. • Configure a replica set in MongoDB. Enable replication in MongoDB and understand the replication process. Add and remove MongoDB instances in replica sets and test the replication process.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
125611	**Cyber Security** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Provide an overview of the field of Cyber Security, including its challenges, constraints, and the role of Internet governance. • Differentiate between various cyber threats, including Cyber Warfare, Cyber Crime, Cyber Terrorism, and Cyber Espionage. • Understand the imperative for a comprehensive Cyber Security policy, the establishment of a nodal authority, and the importance of an international convention on Cyberspace. • Identify vulnerabilities in software, system administration, network architectures, data access, authentication, broadband communications, and poor awareness. • Apply basic security measures for HTTP and SOAP services, understand identity management, authorization patterns, and address challenges in securing web applications. • Identify intrusion types, such as physical theft, privilege abuse, unauthorized access, malware infection, and implement techniques including anti-malware software, network-based intrusion detection/prevention systems, and host-based intrusion prevention systems.		
Module 1	**Introduction to Cyber Security**		1
	LOs: These learning outcomes aim to • Identify and understand vulnerabilities in software, system administration, complex network architectures, open access to organizational data, weak authentication, unprotected broadband communications, and poor Cyber Security awareness. • Demonstrate the ability to conduct security audits, identifying potential weaknesses in systems and networks. • Explain the role of cryptography in Cyber Security and apply cryptographic techniques to secure data communication. • Understand the concept of ethical hacking and its role in proactively identifying and addressing vulnerabilities. • Develop strategies for threat management, including proactive measures and response plans to mitigate the impact of potential cyber threats.	**Module Contents:** • **Introduction to Cyber Security:** Overview of Cyber Security, Internet Governance– Challenges and Constraints, Cyber Threats:- Cyber Warfare-Cyber Crime-Cyber, terrorism-Cyber Espionage, Need for a Comprehensive Cyber Security Policy, Need for a Nodal Authority, Need for an International convention on Cyberspace • **Cyber Security Vulnerabilities and Cyber Security Safeguards:** Cyber Security Vulnerabilities-Overview, vulnerabilities in software, System administration, Complex Network Architectures, Open Access to Organizational Data, Weak Authentication, Unprotected Broadband communications, Poor Cyber Security Awareness. Cyber Security Safeguards-Overview,Accesscontrol,Audit,Authentication,Biometrics,Cryptography, Deception, Denial of Service Filters, Ethical Hacking, Firewalls, Intrusion Detection	

		Systems, Response, Scanning, Security policy, Threat Management.	
Module 2	**Securing Web Application**		1
	LOs: Learners will be able to • Define and explain the roles of services and servers in the context of web applications. • Apply fundamental security measures for HTTP applications, ensuring protection against common vulnerabilities. • Understand identity management principles and implement secure identity practices within web services. • Understand the implications of physical theft as a potential threat and implement measures to prevent or mitigate its impact. • Apply security measures to prevent and detect unauthorized access attempts by external entities.	**Module Contents:** • **Securing Web Application:** Services and Servers Introduction, Basic security for HTTP Applications and Services, Basic Security for SOAP Services, Identity Management and Web Services, Authorization Patterns, Security Considerations, Challenges. • **Intrusion Detection and Prevention:** Intrusion, Physical Theft, Abuse of Privileges, Unauthorized Access by Outsider, Malware infection, Intrusion detection and Prevention Techniques, Anti-Malware software, Network based Intrusion detection Systems, Network based Intrusion Prevention Systems, Host based Intrusion prevention Systems, Security Information Management, Network Session Analysis, System Integrity Validation	
Module 3	**Cryptography and Network Security**		1
	LOs: These learning outcomes aim to • Define cryptography and explain its role in securing information and communication. • Differentiate between symmetric and asymmetric key cryptography, and understand their applications in securing data. • Understand and apply cryptography in various applications, demonstrating proficiency in securing data in different contexts. • Analyze the specificities of the Indian cyber space, including its regulatory framework, challenges, and initiatives.	**Module Contents:** **Cryptography and Network Security:** Introduction to Cryptography, Symmetric key Cryptography, Asymmetric key Cryptography, Message Authentication, Digital Signatures, Applications of Cryptography. Overview of Firewalls- Types of Firewalls, User Management, VPN Security, Security Protocols:-security at the Application Layer-PGP and S/MIME, Security at Transport Layer-SSL And TLS, Security at Network Layer-IPSec. **Cyber space and the Law:** Introduction, Cyber Security Regulations, Roles of International Law, the state and Private Sector in Cyber space, Cyber Security Standards. The INDIAN Cyber space, National Cyber Security Policy 2013.	

Module 4	Analysis of Variance and Co-variance		1
	LOs: learning outcomes aim to • Define Cyber Forensics and understand its significance in investigating cybercrimes and digital incidents. • Demonstrate the ability to initiate and conduct preliminary investigations in response to suspected cyber incidents, ensuring the preservation of digital evidence. • Develop proficiency in conducting disk-based analysis, including the identification, preservation, and analysis of digital evidence stored on computer hard drives and storage media.	**Module Contents:** **Cyber Forensics** Introduction to Cyber Forensics, Handling Preliminary Investigations, Controlling an Investigation, Conducting disk-based analysis, Investigating Information-hiding, Scrutinizing E-mail, Validating E-mail header information, Tracing Internet access, Tracing memory in real-time.	
Assignments/ Activities			
	These assignments and activities are designed to engage students in practical applications of cyber security concepts, fostering critical thinking and skill development throughout the course. • Divide students into groups and assign each group a specific cyber security vulnerability (e.g., software vulnerabilities, weak authentication). Have them research, analyze, and present strategies to mitigate the assigned vulnerability. • Organize a workshop where students present and demonstrate various cyber security safeguards. This can include access control, encryption, firewalls, and intrusion detection systems. Encourage hands-on activities and practical demonstrations. • Assign students a case study involving a web application. They should conduct a security assessment, identify vulnerabilities, and propose safeguards. Emphasize securing HTTP and SOAP services, identity management, and authorization patterns. • Provide case studies related to intrusion incidents. Students should analyze each case, identify the type of intrusion, and propose effective prevention and detection techniques. Encourage discussion on ethical hacking and security policy enforcement. • Provide legal cases related to cyber space and cyber security. Students should analyze the legal implications, court decisions, and the role of international law and regulations. • Assign students to review and critique the National Cyber Security Policy of 2013. They should assess its effectiveness, identify areas for improvement, and propose updated recommendations.	

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<table>
<tr><th>SN</th><th>Courses, Modules and Outcomes</th><th>Course Contents</th><th>Cr</th></tr>
<tr><td></td><td colspan="2">Semester I</td><td></td></tr>
<tr><td>125612</td><td colspan="2">Digital Image Processing
Major (Elective) Theory</td><td>4</td></tr>
<tr><td></td><td colspan="2">Course Outcomes:
Learners will be able to:

• Demonstrate a comprehensive understanding of light, brightness adaptation, discrimination, and the human visual system in the context of digital images.
• Analyze and interpret images as 2D data, distinguishing between grayscale and color representations, and demonstrate proficiency in image sampling and quantization techniques.
• Apply image filtering techniques in both spatial and frequency domains, including concepts such as image smoothing, sharpening, homomorphic filtering.
• Understand the reasons for image degradation, model the image degradation/restoration processes, and implement noise probability density functions.
• Describe color fundamentals, color models, and apply pseudo-color image processing techniques for enhanced visual representation.
• Understand the fundamentals of redundancies and implement basic compression methods.</td><td></td></tr>
<tr><td>Module 1</td><td colspan="2">Fundamentals of Digital Image Processing</td><td>1</td></tr>
<tr><td></td><td>LOs: These learning outcomes aim to

• Understand the concept of light and its role in digital imaging.
• Explore brightness adaptation and discrimination in the context of human vision.
• Examine the basics of the Human Visual System (HVS) and its relevance to image processing.
• Comprehend the representation of images as 2D data.
• Differentiate between gray scale and color images in terms of representation and characteristics.
• Study the concepts of image sampling and quantization.
• Understand the concept of an image histogram and its role in image processing.
• Understand the fundamentals of spatial filtering.
• Explore spatial filtering masks for low-pass filtering (smoothing) and high-pass filtering (sharpening).</td><td>Module Contents:

• Light, brightness adaption and discrimination, Human visual system, Image as a 2D data, Image representation gray scale and color images, Image Sampling and quantization.
• Intensity transformation functions: Contrast stretching, Thresholding, Image negative, Log transformation, Power-low</td><td></td></tr>
</table>

Module 2	**Image Enhancement and Restoration**		1
	LOs: Learners will be able to • Understand preliminary concepts related to image filtering in the frequency domain. • Extend concepts to functions of two variables in the context of image processing. • Explore image smoothing techniques in the frequency domain. • Study image sharpening methods in the frequency domain. • Gain knowledge of 2D-DFT (2-dimensional Discrete Fourier Transform) and its significance. • Learn image restoration using spatial filtering techniques such as mean filters, order statistic filters, and adaptive filters.	**Module Contents:** • **Image filtering in the Spatial and frequency domain:** Preliminary Concepts, Extension to functions of two variables, Image Smoothing, Image Sharpening, Homomorphic filtering,2D-DFT, 2DFFT, 2D-DCT, Fundamentals of 2D-wavelet transform, Image pyramids, sub-band coding. • **Image restoration:** Reasons for image degradation, Model of image degradation/ restoration process, Noise probability density functions, Image restoration using spatial filtering (Mean filters, Order statistic filters and adaptive filters), Inverse Filtering, MMSE (Wiener)Filtering	
Module 3	**Colour Image Processing and Image Compression**		1
	LOs: These learning outcomes aim to • Demonstrate a comprehensive understanding of color fundamentals, including the concepts of color spaces, color models, and the perceptual aspects of color. • Analyze and apply various color models, such as RGB, CMYK, and HSL, to represent and manipulate color information in digital images. • Understand the fundamental concepts of redundancies in digital images and recognize opportunities for compression. • Understand and apply wavelet-based compression techniques for both lossless and lossy compression, considering their advantages in preserving image details.	**Module Contents:** • **Color Image Processing:** Color Fundamentals, Color Models, Pseudo-color image processing. • **Image Compression:** Fundamentals of redundancies, Basic Compression Methods: Huffman coding, Arithmetic coding, LZW coding, JPEG Compression standard, Wavelet based image compression.	
Module 4	**Image Segmentation and Morphological Image Processing**		1
	LOs: learning outcomes aim to • Understand the concept of edge-based segmentation in image processing. • Explore region-based segmentation techniques and their applications.	**Module Contents:** • **Image Segmentation:** Edge based segmentation, Region based segmentation, Region split and merge techniques, Region growing by pixel aggregation, optimal thresholding.	

	• Gain knowledge about region split and merge techniques for image segmentation. • Understand the region-growing approach using pixel aggregation. • Understand the basic principles of morphological operations in image processing. • Explore the concept of structuring elements and their role in morphological operations. • Explore basic morphological algorithms, including holefilling and connected components.	• **Morphological Image Processing:** Basic morphological operations, Erosion, dilation, opening, closing, Structuring elements, Hit-or-Miss transform, Basic Morphological Algorithms: hole filling, Connected components, thinning, skeletons, Reconstruction by erosion and dilation	
Assignments/ Activities			
	• Apply fundamental image enhancement techniques to improve the visual quality of a given grayscale image. • Select a grayscale image with varying intensity levels. • Implement contrast stretching, histogram equalization, and gamma correction on the image. • Provide visual comparisons of the original image and the enhanced versions. • Explain the impact of each enhancement technique on image quality. • Discuss potential applications where each technique might be beneficial. • Implement basic image compression algorithms and evaluate their impact on image quality and file size. • Select a high-resolution color image for compression. • Implement Huffman coding for lossless compression and evaluate the compression ratio. • Apply JPEG compression with different quality settings and observe the trade-off between compression ratio and image quality. • Compare the original and compressed images visually. • Discuss the strengths and limitations of each compression method. • Assignments based on important topics, spatial and frequency domain filtering		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
125613	**Software Engineering** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand structured development methodologies and various models like agile or waterfall. • Recognize the pivotal role of Software Requirements Specification (SRS) in documenting software needs. • Estimate costs, create timelines, allocate resources efficiently, implement quality assurance, and manage risks. • Adhere to effective coding, thorough verification, and engage in testing methodologies. • Demonstrate knowledge beyond development, covering maintenance, risk management, and project management concepts.		
Module 1	**Software Processes, Software Requirement Analysis and Specification**		1
	LOs: These learning outcomes aim to • Understand the concepts of software processes, projects, and products. • Examine component software processes and their roles in the development lifecycle. • Identify the characteristics of a software process and how they influence project outcomes. • Investigate the software configuration management process and its importance. • Define software requirements and recognize the need for Software Requirement Specification (SRS). • Understand other modeling approaches, such as prototyping, and their relevance to requirement analysis. • specification languages and their application in documenting requirements. • Examine the structure of a requirement document and its components.	**Module Contents:** • **Software Processes:** Processes projects and products, Component software processes, characteristics of a software process, software Development Process, project management process, software configuration management process, software configuration management process, and process management process • **Software requirement Analysis and Specification:** Software requirement, need for SRS, requirement process, problem analysis, analysis issues. Informal approach, structured analysis, object-oriented modelling, other modelling approaches, prototyping, requirement specification, characteristics of an SRS, component of an SRS, specification languages, structure of requirement document validation requirement reviews, other method metrics, size measures, quality metrics	
Module 2	**Planning Software Project and Coding**		1
	LOs: Learners will be able to • Understand best practices in coding and programming. • Explore verification techniques in coding. • Identify size measures in the context of coding and	**Module Contents:** • **Planning Software Project:** Cost estimation, uncertainties in cost estimation, building cost estimation models, on size estimation, COCOMO model, project scheduling, average	

	programming. • Perform complexity analysis in coding. • Understand the fundamentals of software testing. • Explore white-box testing techniques. • Understand control structure testing and its role in software testing. • Explore black-box testing techniques. • Understand basis path testing in the context of software testing. • Explore code walk-throughs and inspections in the testing process. • Understand different testing strategies and the associated issues. • Explore unit testing in software development. • Understand integration testing and its significance.	duration estimation, project scheduling and milestones, staffing and personnel planning, ray leigh curve, personnel plan, team structure, software configuration management plans, quality assurance plans, verification and validation, project monitoring plans, risk management. • **Coding:** Programming practice, verification, size measures, complexity analysis, coding standards. Testing– fundamentals, white box testing, control structure testing, black box testing, basis path testing, code walk-throughs and inspection, testing strategies- Issues, Unit testing, integration testing, Validation testing, System testing	
Module 3	**Maintenance**		1
	LOs: These learning outcomes aim to • Understand the overall process of software maintenance and its significance in the software development lifecycle. • Identify and differentiate between various types of maintenance activities. • Explore the challenges and considerations involved in software maintenance. • Define software risks and recognize their impact on software projects. • Explore techniques for identifying potential risks in software projects. • Understand the process of monitoring and managing software risks. • Understand the fundamental concepts of project management. • Explore the interplay between people, product, process, and project in the context of software development.	**Module Contents:** • **Maintenance**: Overview of maintenance process, types of maintenance. Risk management: software risks-risk identification-risk monitoring and management. Project Management concept: People–Product-Process-Project.	
Module 4	**Protection and Security**		1
	LOs: Learners will be able to • Understand the basic concepts of project scheduling and tracking in	**Module Contents:** • **Project scheduling and tracking:** Basic concepts-	

	software development. • Explore the relationship between people and effort in the context of project scheduling. • Learn how to define a task set for a software project, considering the scope, complexity, and dependencies. • Understand the basics of software configuration management (SCM) and its importance in software development. • Explore industry standards and best practices in software configuration management. • Understand the basics of CASE tools and their role in the software development lifecycle. • Explore the rules and principles of user interface design in the context of software development. • Learn about the building blocks of CASE tools and how they contribute to the development process.	relation between people and effort-defining task set for the software project-selecting software engineering task Software configuration management: Basics and standards User interface design-rules. Computer aided software engineering tools-CASE building blocks, taxonomy of CASE tools, integrated CASE environment.	
Assignments/ Activities			
	These assignments aim to cover diverse aspects of software engineering. • Choose a software project scenario and develop a project schedule, considering task dependencies and the allocation of resources. Discuss the challenges and benefits of the chosen scheduling approach. • Investigate the relationship between the effort required for project tasks and the team involved. Propose strategies for optimizing team efficiency while ensuring project success. • Define a task set for a hypothetical software project. Consider factors such as task complexity, dependencies, and critical path analysis. Justify your choices in the task set. • Research and document the basics of software configuration management, including its key principles and objectives. Explain how effective SCM contributes to successful software development. • Explore industry standards for software configuration management. Compare and contrast different standards, highlighting their advantages and limitations. • Investigate the building blocks of CASE tools and how they contribute to the software development process. Provide examples of each building block in action. • Develop a taxonomy of CASE tools, categorizing them based on their functions and applications. Discuss the advantages and limitations of different types of CASE tools.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
125614	**Artificial Intelligence** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Demonstrate an overview of Artificial Intelligence, recognizing its importance in various fields. • Trace the historical development of AI and identify related fields. • Explain different methods of representing knowledge in AI. • Understand and apply knowledge base systems. • Analyze state space search problems using examples like the 8-Queens, Traveling Salesman, and others. • Understand adversarial search in game scenarios. • Implement the minimax algorithm and comprehend Alpha-Beta Pruning for optimizing game strategies. • Represent simple facts using logic. • Understand computable functions in predicates. • Apply resolution and unification techniques. • Differentiate between forward and backward reasoning.		
Module 1	**Introduction to Artificial Intelligence**		1
	LOs: These learning outcomes aim to • Demonstrate a comprehensive understanding of Artificial Intelligence (AI), including its definition, objectives, and significance in various domains. • Trace the historical development of AI, identifying key milestones, breakthroughs, and influential figures in the field. • Explain various methods of representing knowledge in AI, including symbolic, semantic, and sub-symbolic approaches. • Implement and interpret Knowledge Base Systems for organizing and managing information.	**Module Contents:** **Introduction:** • Overview of AI, Importance of AI, History, related fields, Representation of Knowledge, Knowledge Base Systems, State Space Search Problem Characteristics of 8- Queens, Traveling Salesman, Missionary & Cannibals, Crypt, Arithmetic, Monkey Banana Problem, Tower of Hanoi and Block World.	
Module 2	**Searching Methods and Predicate & Logic**		1
	LOs: Learners will be able to • Implement DFID to combine the advantages of DFS and BFS. • Assess the efficiency of DFID in terms of time and space complexity. • Apply Greedy Best-First Search to solve optimization problems. • Analyse the role of heuristic functions in guiding the search process. • Implement Hill Climbing Search	**Module Contents:** **Searching Methods:** • Uninformed Search Methods: Breadth First Search (BFS), Depth First Search (DFS), Depth Limited Search, Depth First Iterative Deepening (DFID), • Informed Search Methods: Greedy best first Search, A* Search, Memory bounded heuristic Search.	

	for local optimization. • Recognize the limitations and challenges associated with hill climbing. • Apply genetic algorithms for optimization and problem-solving. • Understand the principles of genetic algorithms and their application in various domains. • Represent and manipulate simple facts using propositional and first-order logic. • Understand the syntax and semantics of logic representations	• Local Search Algorithms and Optimization Problems: Hill climbing search Simulated annealing, Local beam search, Genetic algorithms. • Adversarial Search: Games, Optimal strategies, The minimax algorithm, Alpha-Beta Pruning. **Predicate & Logic:** • Representing simple facts in Logic -Computable functions in predicates, resolution – unification • – forward vs. backward reasoning., Probabilistic reasoning – Bayes's Theorem – Certainty Factors– Demphster–Shafer Theory – Fuzzy, Sets, Reasoning with Fuzzy Logic, Natural Language Computation with Fuzzy Logic.	
Module 3	**Structured Knowledge Representation and Introduction to Natural Language Processing**		1
	LOs: These learning outcomes aim to • Explain the concept of associative networks in structured knowledge representation. • Implement and interpret associative networks for organizing and retrieving information. • Design and implement frame structures for organizing complex knowledge representations. • Analyze the role of frames in representing attributes, relationships, and hierarchies • Provide an overview of linguistics and its relevance to natural language processing. • Understand key linguistic concepts that influence language understanding.	**Module Contents:** • **Structured Knowledge Representation:** Associative Networks, Semantic Nets, Frames Structures, Conceptual, Dependencies & Scripts, Learning – Concept of Learning – Learning Automata, Learning by induction. • **Natural Language Processing**: Overview of Linguistics, Grammars and Languages, basic Parsing techniques, semantic analysis, and representation structures. Natural Language generation and Natural Language Systems.	
Module 4	**Expert System**		1
	LOs: learning outcomes aim to • Understand the architecture of expert systems, including knowledge representation, inference engines, and user interfaces.	**Module Contents:** **Expert Systems:** • Architecture – Need and Justification of • Expert Systems –Knowledge acquisition and validation.	

	• Design and implement an expert system architecture for specific problem domains. • Recognize and justify the need for expert systems in various industries and applications. • Evaluate the advantages and limitations of expert systems compared to traditional problem-solving approaches.	Perception and Action, Real time search, perception, action, vision, robot architecture, Learning in Neural Networks – Applications – Hopfield Networks, Back propagation, • Case Study - XCON, PROSPECTOR	
Assignments/ Activities			
	Recognize and analyse the practical applications of AI in everyday life. • Identify three applications of AI in daily life (e.g., virtual assistants, recommendation systems, smart home devices). • Describe how each application uses AI techniques. • Discuss the impact of these AI applications on efficiency, convenience, and user experience. • Reflect on potential ethical considerations associated with the use of AI in these applications. • Choose three AI algorithms (e.g., Decision Trees, Neural Networks, Genetic Algorithms). • Explain the working principles of each algorithm. • Compare and contrast their strengths, weaknesses, and applications. • Provide examples of real-world problems each algorithm can solve effectively		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
125615	**Database Management System For Data Science** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • To develop conceptual understanding of database management system. • To understand how a real-world problem can be mapped to schemas • To solve different industry level problems & to learn its applications • To learn how to handle structured and unstructured data • To learn how to do Data Analysis and Process the Data using MongoDB • To define a problem at the view level & ability to understand the physical structure of the database to handle data • Implement the logic for Data Manipulation using SQL Query • Normalize the database & understand the internal data structure • Understand the transaction system & could extract data efficiently		
Module 1	**Introduction**		1
	LOs: Learners will be able to • Connect and interact with various data sources, including relational databases and dimensional data warehouses. • Apply SQL commands for data storage and modification, including creating, inserting, updating, and deleting records. • Execute fundamental SQL statements, such as sorting rows and performing inline calculations. • Proficiently use the WHERE clause, subqueries, and CASE statements for filtering, advanced querying, and conditional operations in SQL.	**Module Contents:** • **Data Sources:** Introduction to Data Sources, Tools for connecting Data Sources, Relational Databases, Dimensional Data Warehouses. • **Storing and Modifying Data:** Create, Insert, Update, Delete Select Statement: Fundamental Syntax, Sorting rows, Simple inline calculations, Complex inline calculations • **where Clause:** Filtering SELECT statement results, Filtering on Multiple conditions, Use of BETWEEN, IN, LIKE, IS NULL, Subqueries with filtering • **Case Statement:** Syntax, Binary flags using Case, Grouping using Case	
Module 2	**Data Analysis with SQL**		1
	LOs: Learners will be able to • Master the concept of joins, understanding different types and effectively joining multiple tables in SQL. • Demonstrate proficiency in exploratory data analysis (EDA) with SQL, including examining column values,	**Module Contents:** • **Join:** Introduction, Types of join, joining two or more tables. Date and Time Functions • **Exploratory Data Analysis with SQL**: Demonstrating Exploratory Data Analysis with SQL, Exploring Possible	

	tracking changes over time, and exploring multiple tables simultaneously. • Develop the ability to build SQL datasets for analytical reporting, considering dataset requirements, using custom datasets, and leveraging Common Table Expressions (CTEs) and views to enhance SQL reporting capabilities.	Column Values, Exploring Changes Over Time, Exploring Multiple Tables Simultaneously • **Building SQL Datasets for Analytical Reporting**: Thinking Through Analytical Dataset Requirements, Using Custom Analytical Datasets in SQL, CTEs and Views, Taking SQL Reporting Further	
Module 3	**Data Augmentation Using SQL**		1
	LOs: Learners will be able to • Master advanced query structures, including the use of UNIONs, self-joins for determining to-date maximum values, and counting new vs. returning data. • Develop skills in creating machine learning datasets using SQL, specifically for time series models and binary classification. • Apply techniques for dataset creation, expansion of feature sets, and feature engineering within SQL. • Demonstrate proficiency in developing analytical datasets, supported by practical examples and applications in the context of machine learning	**Module Contents:** • More Advanced Query Structures: UNIONs, Self-Join to Determine To-Date Maximum, Counting New vs. Returning • Creating Machine Learning Datasets Using SQL: Datasets for Time Series Models, Datasets for Binary Classification, Creating the Dataset, Expanding the Feature Set, Feature Engineering, Analytical Dataset Development Examples	
Module 4	**Unstructured Database**		1
	LOs: Learners will be able to • Understand unstructured databases, exploring their advantages and comparing them to structured databases, while gaining insights into diverse data models like JSON and XML. • Master MongoDB, covering its installation, database management, query language, and aggregation capabilities, recognizing optimal use cases. • Acquire advanced Database Management System (DBMS) skills, including stored procedures, triggers, data models, and various types of indexes, while comprehending concepts like replication and sharding for distributed data storage.	**Module Contents:** • Unstructured Database: Introduction, Advantages of unstructured Database, Comparison between structured and unstructured database • MongoDB : Introduction, When to use MongoDB, Installation, Databases, Collections Documents, MongoDB query language, Aggregation • NO SQL, JSON, XML, etc • Advance DBMS – Stored Procedure, Triggers • Data Models: Introduction, Schema validation, Data model examples and Patterns • Indexes: Single field, Compound field, Text, Wildcard, 2dsphere, geoHaystack • Replication: Replica Set Members, Replica Set Oplog, Replica Set	

		• Data Synchronization Sharding: Shared Cluster Components, Shared Keys, Zones, Data , Partitioning with Chunks, Balancer	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Explore MongoDB by installing it, creating databases, collections, and documents. • Execute MongoDB queries and understand the aggregation framework. • Compare NoSQL databases like MongoDB with traditional databases, understanding JSON and XML data models. • Develop a schema validation exercise to enforce data integrity in MongoDB. • Implement various types of indexes (single field, compound field, text, etc.) and evaluate their impact. • Explore MongoDB replication by configuring a replica set and understanding the oplog. • Set up data synchronization in a MongoDB replica set, managing members and oplog functionality. • Experiment with sharding in a shared cluster, understanding components, keys, zones, and the balancing process.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester I		
135611	**Research Methodology: Theory** **Minor Stream(RM)**		**4**
	Course Outcomes: **Learners will be able to:** • Demonstrate an understanding of the key steps involved in the research process, including problem formulation, literature review, data collection, analysis, and interpretation. • Formulate clear and focused research questions and hypotheses based on a thorough review of existing literature and identification of research gaps. • Evaluate and select suitable research designs based on the nature of the research questions, including experimental, quasi-experimental, and non-experimental designs. • Conduct comprehensive literature reviews to identify relevant studies, theories, and methodologies within a specific research domain. • Develop and design appropriate tools for data collection, such as surveys, interviews, or experiments, ensuring validity and reliability. • Apply basic statistical techniques for data analysis, interpretation, and drawing meaningful conclusions from research findings • Understand and adhere to ethical considerations in research, including the responsible conduct of research, protection of human subjects, and avoidance of plagiarism.		
Module 1	**Introduction to Research methodology**		1
	LOs: These learning outcomes aim to • Understand the fundamental meaning of research and its role in acquiring knowledge and solving problems. Identify the primary objectives of research, including the pursuit of knowledge, problem-solving, and contributing to existing knowledge. • Develop the skills necessary to define a clear and focused research problem, including the identification of gaps in existing literature and formulating relevant research questions. • Define a hypothesis and recognize its role as a tentative explanation or prediction that guides the research.	**Module Contents:** • **Foundations of Research:** Meaning, Objectives, Motivation, Utility. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable Research Process. • **Problem Identification & Formulation** – Research Question – Investigation Question. • **Measurement Issues** – Hypothesis – Qualities of a good Hypothesis –Null Hypothesis & Alternative Hypothesis. Hypothesis Testing – Logic & Importance	
Module 2	**Measurement and Scale**		
	LOs: Learners will be able to • Define research design and	**Module Contents:** • Research Design: Concept and	

	recognize its crucial role in shaping the structure and execution of research studies. • Understand the concept of exploratory research, its types, and its applications in uncovering new insights and generating hypotheses. • Define qualitative research and understand its emphasis on exploring the depth and complexity of phenomena. Recognize the concepts of measurement, causality, generalization, and replication in the context of qualitative research. • Define scaling in the context of research and recognize its importance in measuring attitudes, opinions, and other abstract concepts.	Importance in Research – Features of a good research design – Exploratory Research Design – concept, types and uses, Descriptive Research Designs – concept, types and uses. Experimental Design: Concept of Independent & Dependent variables. • **Qualitative and Quantitative Research:** Qualitative research – Quantitative research – Concept of measurement, causality, generalization, replication. Merging the two approaches. • **Measurement and Scale: Concept of measurement**– what is measured? Problems in measurement in research – Validity and Reliability. Measurement Scale – Nominal, Ordinal, Interval, Ratio.	
Module 3	**Sampling**		1
	LOs: These learning outcomes aim to • Define the sampling frame and its role as a list or framework from which the actual sample is drawn. • Understand the factors influencing sample size determination and its significance in achieving reliable results. • Examine the key characteristics that contribute to the representativeness, reliability, and validity of a good sample in research. • Define and understand the process of selecting a simple random sample and its application in ensuring each element has an equal chance of being included.	**Module Contents:** • **Sampling:** Concepts of Statistical Population, Sample, Sampling Frame, Sampling Error, Sample Size, Non Response. Characteristics of a good sample. Probability Sample – Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage sampling. Determining size of the sample, Practical considerations in sampling and sample size.	
Module 4	**Data Analysis**		1
	LOs: learning outcomes aim to • Understand the importance of data preparation in ensuring the quality and reliability of data for analysis.	**Module Contents:** • **Data Analysis:** Data Preparation – Univariate analysis (frequency tables, bar charts, pie charts, percentages), Bivariate analysis –	

	• Learn the essential components and structure of a research paper, including title, abstract, introduction, methodology, results, discussion, and conclusion. • Explore the effective use of reference materials such as encyclopedias, research guides, handbooks, and other resources to enhance research quality.Apply effective communication skills in presenting data science findings through a case study presentation.	Cross tabulations and Chi-square test including testing hypothesis of association. • **Interpretation of Data and Paper Writing** – Layout of a Research Paper, Journals in Computer Science, Impact factor of Journals, When and where to publish ? Ethical issues related to publishing, Plagiarism and Self-Plagiarism. • **Use of Encyclopedias, Research Guides, H**andbook etc., Academic Databases for Computer Science • **Business Communication for Data Science** (Case Study-Presentation)	
Assignments/ Activities			
	These assignments and activities are designed to engage students in practical applications of research methodology concepts, fostering critical thinking and skill development throughout the course. • Research Proposal Development: Assignment: Ask students to develop a research proposal for a hypothetical research study. The proposal should include a clear research problem statement, objectives, literature review, research questions/hypotheses, methodology, and potential challenges. • Critical Analysis of Research Articles: Activity: Provide students with a set of research articles from different disciplines. Ask them to critically analyze the methodology section, identifying strengths and weaknesses, and discussing how they would improve the research design. • Survey Design and Implementation: Assignment: Have students design a survey on a topic of their choice. They should consider question wording, response options, and survey structure. After designing the survey, ask them to administer it to a small sample and analyze the results. • Qualitative Research Design: Activity: Assign students a qualitative research design task. They can choose a research question and develop a plan for data collection (e.g., interviews, focus groups, observation). Emphasize the importance of reflexivity and ethical considerations. • Sampling Exercise: Assignment: Provide a scenario where a specific sampling strategy is needed (e.g., population survey, clinical trial). Ask students to justify their choice of sampling method, discuss potential biases, and propose alternatives. • Data Analysis with Statistical Software: Activity: Introduce students to statistical software (e.g., SPSS, R) and provide a dataset. Ask them to perform basic data analysis, including descriptive statistics and inferential tests. Emphasize interpretation of results. • Ethical Dilemmas in Research: Assignment: Present students with various ethical dilemmas related to research (e.g., informed consent, data confidentiality). Ask them to analyze the dilemmas, propose solutions, and discuss the implications of their decisions. • Peer Review Simulation: Activity: Have students conduct a peer review of a research proposal or a manuscript. This can include evaluating the clarity of the research		

	question, appropriateness of methodology, and overall rigor of the study. • Research Presentation: Assignment: Ask students to create a presentation summarizing a research paper. They should highlight the key elements of the study, discuss the methodology, and present the findings. Encourage a focus on effective communication. • Case Study Analysis: Activity: Provide students with a research-related case study involving methodological challenges. Ask them to analyze the case, identify issues, and propose solutions based on their understanding of research methodology.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
215611	**DATA MINING WITH ANALYTICS** **Major (Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** ● Learn core data mining concepts, automation strategies, and dimension reduction techniques. ● Master association rule discovery with algorithms like Apriori and delve into collaborative filtering for user and item-based recommendations. ● Handle time series data through forecasting methods, smoothing techniques, and explore social network analytics and text mining for comprehensive data analysis.		
Module 1	**OVERVIEW OF THE DATA MINING PROCESS**		1
	LOs: Learners will be able to: ● Grasp the fundamentals of data mining, including core concepts like classification, prediction, and recommendation systems. ● Understand the significance of predictive analytics and the essential steps in the data mining process. ● Gain proficiency in automating data mining solutions for efficient analysis. ● Address dimensionality challenges through techniques such as curse of dimensionality, correlation analysis, and dimension reduction methods like principal components.	**Module Contents:** **Overview of the Data Mining Process:** ● Introduction, Core Ideas in Data Mining, Classification, Prediction, Association Rules and Recommendation Systems, Predictive Analytics, The Steps in Data Mining, Automating Data Mining Solutions, ● Dimension Reduction: Introduction, Curse of Dimensionality, Correlation Analysis, Reducing the Number of Categories in Categorical Variables, Converting a Categorical Variable to a Numerical Variable, Principal Components, Normalizing the Data	
Module 2	**MINING RELATIONSHIPS AMONG RECORDS**		1
	LOs: Learners will be able to ● Upon completion of this module, participants will grasp association rules, including their discovery in transaction databases and practical application in scenarios like phone faceplate purchases. ● Proficiency in generating candidate rules using the Apriori algorithm, selecting strong rules, and understanding collaborative filtering's	**Module Contents:** ● **Association Rules**: Association Rules ,Discovering Association Rules in Transaction Databases , Example 1: Synthetic Data on Purchases of Phone Faceplates , Generating Candidate Rules , The Apriori Algorithm ,Selecting Strong Rules , Data Format , The Process of Rule Selection , Interpreting the Results ,Rules and Chance , Example 2: Rules for Similar Book Purchase	

	advantages and weaknesses will be achieved.	• Collaborative Filtering, Data Type and Format ,Example 3: Netflix Prize Contest , User-Based Collaborative Filtering: "People Like You" , Item-Based Collaborative Filtering , Advantages and Weaknesses of Collaborative Filtering , Collaborative Filtering vs, Association Rules.	
Module 3	**FORECASTING TIME SERIES**		1
	LOs: These learning outcomes aim to • Differentiate between descriptive and predictive modeling in time series analysis. • Master popular forecasting methods and understand the significance of combining diverse techniques. • Acquire skills in handling time series components through a practical example on Amtrak train ridership. • Learn data partitioning, benchmarking performance with naive forecasts, and generating future forecasts. • Gain proficiency in smoothing methods, including moving averages, centered moving averages, and exponential smoothing, considering factors like window width and smoothing parameters. Understand the application of these techniques in various time series scenarios.	**Module Contents:** • **Handling Time Series**: Introduction, Descriptive vs, Predictive Modeling , Popular Forecasting Methods in Business , Combining Methods , Time Series Components , Example: Ridership on Amtrak Trains , Data-Partitioning and Performance Evaluation , Benchmark Performance: Naive Forecasts , Generating Future Forecasts **Smoothing Methods**: Introduction ,Moving Average , Centered Moving Average for Visualization , Trailing Moving Average for Forecasting , Choosing Window Width (w) , Simple Exponential Smoothing , Choosing Smoothing Parameter α , Relation Between Moving Average and Simple Exponential Smoothing , Advanced Exponential Smoothing ,Series with a Trend , Series with a Trend and Seasonality ,Series with Seasonality (No Trend)	
Module 4	**DATA ANALYTICS**		1
	LOs: Learners will be able to • Grasp social network analytics concepts, differentiating directed and undirected networks. • Master visualization techniques, graph layouts, and utilizing network data for classification and prediction. • Acquire skills in text mining,	**Module Contents:** **Social Network Analytic**s: Introduction , Directed vs, Undirected Networks , Visualizing and Analyzing Networks, Graph Layout , Edge List , Adjacency Matrix , Using Network Data in Classification and Prediction ,	

	understanding term-document matrices, and applying preprocessing methods for meaningful data extraction.	Social Data Metrics and Taxonomy , Node-Level Centrality Metrics , Egocentric Network , Network Metrics , Using Network Metrics in Prediction and Classification , Link Prediction , Entity Resolution. **Text Mining**: Introduction , The Tabular Representation of Text: Term-Document Matrix and "Bag-of-Words" , Bag-of-Words vs, Meaning Extraction at Document Level , Preprocessing the Text , Tokenization , Text Reduction , Presence/Absence vs, Frequency , Term Frequency–Inverse Document Frequency (TF-IDF) , From Terms to Concepts: Latent Semantic Indexing , Extracting Meaning , Presence/Absence vs, Frequency ,Term Frequency–Inverse Document Frequency (TF-IDF) , From Terms to Concepts: Latent Semantic Indexing , Extracting Meaning.	
Assignments/ Activities			
	• Data Mining Concepts Quiz : Evaluate understanding of data mining fundamentals, including classification, prediction, and recommendation systems. • Dimension Reduction Exercise : Apply techniques to address the curse of dimensionality and reduce categorical variables, demonstrating proficiency in dimension reduction. • Association Rules Case Study : Analyze synthetic data on phone faceplate purchases, generating and selecting strong rules using the Apriori algorithm. • Collaborative Filtering Assignment : Explore the Netflix Prize Contest, contrasting user-based and item-based collaborative filtering, and evaluating their advantages and weaknesses. • Time Series Analysis Project : Analyze Amtrak train ridership, applying forecasting methods and assessing performance through data partitioning and benchmarking. • Smoothing Methods Workshop : Choose and apply moving average and exponential smoothing techniques to time series data with trends or seasonality. • Social Network Analytics Project : Visualize and analyze directed and undirected networks, utilizing network metrics for classification, prediction, and link prediction. • Text Mining Practical : Develop a term-document matrix and apply preprocessing techniques, including tokenization and text reduction, for meaningful data extraction. • Latent Semantic Indexing Activity : Apply TF-IDF and Latent Semantic Indexing to transform terms into concepts, extracting meaning from textual data. • Integrated Project : Combine concepts learned across modules to		

	solve a real-world problem, utilizing data mining, time series analysis, social network analytics, and text mining techniques.	

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Dr. Ossama Embarak, Data Analysis and Visualization using Python, Apress.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
215612	**Applied Artificial Intelligence** **Major (Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand the Role of AI • Programming in AI • Soft Computing Concepts • Understanding Genetic Algorithms		
Module 1	**An Introduction to AI & Expert System**		1
	LOS: Learners will be able to • Describe the role of AI in engineering and its applications in daily life. • Differentiate between intelligence and artificial intelligence. • Identify various task domains of AI and discuss their significance. • Explain different programming methods used in AI. • Analyze and discuss the limitations and challenges of AI.	**Module Contents:** **Artificial Intelligence** : Role of AI in engineering, AI in daily life, Intelligence and Artificial Intelligence, Different task domains of AI, Programming methods, Limitations of AI **Expert System and Applications:** Phases in Building Expert System, Expert System Architecture, Expert System versus Traditional Systems, Rule based Expert Systems, Blackboard Systems, Truth Maintenance System, Application of Expert Systems, Shells and Tools .	
Module 2	**Introduction to Soft Computing, Fuzzy Logic & Defuzzification**		1
	LOs: Learners will be able to • Define Soft Computing • Understand the concept of soft computing and its significance in solving complex problems. • Differentiate Soft Computing and Hard Computing • Identify and explain the distinctions between soft computing and hard computing approaches. • Supervised and Unsupervised Learning • Main Components of Soft Computing:	**Module Contents:** **Importance of soft computing** Soft computing versus hard computing; Supervised and unsupervised learning; Introduction to main components of soft computing: Fuzzy logic, Neural networks, Genetic algorithms **Fuzzy Sets and Fuzzy Logic:** Fuzzy Sets, Fuzzy set operations, Types of Membership Functions, Multivalued Logic, Fuzzy Logic, Linguistic variables and Hedges, Fuzzy propositions, inference rules for fuzzy propositions, fuzzy systems, possibility theory and other enhancement to Logic	
Module 3	**Neural Network, Genetic Algorithm & ANN**		1
	LOs: Learners will be able to • Define Neural Networks • Understand the fundamental	**Module Contents:** **Basic concepts of Neural network:** Overview of learning rules	

	concepts of neural networks. • Provide an overview of learning rules and parameters governing neural network training. • Explain various activation functions used in neural networks. • Single Layer Perceptron and Multilayer Perceptron • Implement and understand the workings of both single-layer perceptron and multilayer perceptron models.	and parameters; Activation functions; Single layer perceptron and multilayer perceptron. **Basic concepts Genetic Algorithms:** What is Genetic Algorithm, Difference between traditional algorithms and Genetic Algorithm (GA); Basic concepts of GA; GA Operators: Reproduction, Crossover, Mutation; Convergence of GA. **Artificial Neural Network**: Introduction, Fundamental Concept, Artificial Neural Network, Brain vs. Computer - Comparison Between Biological Neuron and Artificial Neuron, Basic Models of Artificial Neural Network	
Module 4	**Intelligent Agents and Artificial Intelligence on the Cloud**		1
	LOs: Learners will be able to • Differentiate between intelligent agents and traditional software programs. • Classify different types of agents based on their characteristics and functionalities. • Explain the working principles of intelligent agents and their decision-making processes. • Compare and contrast single-agent and multi-agent systems, understanding their advantages and limitations.	**Module Contents:** **Intelligent Agents:** Agents vs software programs, classification of agents, working of an agent, single agent and multi-agent systems, performance evaluation, architecture, agent communication language, applications. **Artificial Intelligence on the Cloud** Why are companies migrating to the cloud? The top cloud providers Amazon Web Services: Amazon SageMaker Microsoft Azure: Machine Learning Studio	
Assignments/ Activities			
	• Provide a mathematical optimization problem. • Ask students to use a genetic algorithm to find the optimal solution. • Have them analyze the results and compare them with traditional optimization methods. • In a lab setting, guide students through implementing a basic neural network using a programming language like Python. • Explore different activation functions and discuss the impact on the network's performance.		

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Deva, Rahul. *Artificial Intelligence: A Rational Approach*. Shroff Publishers, 1st edition.

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
215613	**Introduction to Data Science** **Major (core) Theory**		**2**
	Course Outcomes: **Learners will be able to:** • Recognizing different types and sources of data, along with the ability to collect and analyze it. • Understanding various statistical concepts like distributions, hypothesis testing, confidence intervals, and correlation. • Familiarity with various machine learning algorithms such as Linear Regression, Logistic Regression, Decision Trees, Clustering, etc. • Application of text mining techniques to analyze unstructured data, possibly including hands-on lab sessions for practical understanding.		
Module 1	**Introduction to Data &Data transformation AND Python concepts used in data Science**		1
	LOs: Learners will be able to • Identify and differentiate between various types of data • Illustrate the stages within the Data Science lifecycle and their significance in problem-solving. • Construct models for predictive or descriptive purposes based on analyzed data. • Implement feature extraction methodologies to enhance model performance and interpretability. • Perform various mathematical operations efficiently on NumPy arrays. • Comprehend the data structures provided by Pandas (Series, DataFrame) and their applications in data analysis. • Execute merging operations to combine datasets efficiently for comprehensive analysis. • Apply various types of joins effectively to merge datasets based on common columns or indices.	**Module Contents :** • What is Data? Different kinds of data, Data Sources, Different types of data sources, • Exploratory Data Analysis (EDA), Data Science lifecycle, Data Collection • Data Extraction, Data Analysis & Modeling, • Data transformations: Dimension reduction, Feature extraction, Smoothing and aggregating. • The World of arrays with Numpy: creating an array, Mathematical operations, Indexing and slicing, Shape manipulation. • Empowering Data analysis with pandas: the data structure of pandas, Inserting and exporting data, • Data Cleansing: checking missing data, filling missing data, merging operations • Data Operations: Aggregation operations, Joins	
Module 2	**Inferential Statistics ,Data Visualisation AND Machine Learning basics**		1
	LOs: Learners will be able to • Identify and differentiate between various probability distributions (normal, binomial,	**Module Contents :** • Inferential Statistics: Various forms of distribution, z-score, p-value, Type 1 and Type 2 errors,	

	Poisson, etc.) and their real-world applications. • Control line properties in various chart types for better visualization. • Differentiate between various types of Machine Learning (supervised, unsupervised, reinforcement learning). • Implement User-Based Collaborative Filtering techniques for generating recommendations based on user similarities. • Explain the theory behind text mining and its applications in analyzing unstructured data.	Confidence Interval, Correlation, Chi-square distribution, ANOVA • Making Sense of Data Through Visualization: Controlling the line properties of a chart, creating multiple plots, styling your plots, Boxplots, Heatmaps, Scatter plots with histogram, Bubble charts • Uncovering Machine Learning: Different types of Machine Learning, Linear Regression, Logistic Regression, Decision Tree, K-means Clustering, Hierarchical Clustering • Generating Recommendations Systems: User Based collaborative filtering, Item Based collaborative filtering, Context Based filtering • Case Study Theory: Analyzing Unstructured Data using Text mining techniques. (Case Study Practical Implementation to be performed in lab as part of Practical's)	
Assignments/ Activities			
	These assignments aim to encouraging practical application and critical thinking. • Students research and present on various types of data sources, their advantages, and limitations. • Given a dataset, apply dimension reduction, feature extraction, and smoothing/aggregation methods. Explain the impact of each transformation on the dataset. • Solve coding exercises using NumPy and Pandas to manipulate arrays, perform data operations, and handle missing data. • Analyze a dataset statistically, calculate z-scores, p-values, and confidence intervals. Interpret the findings and make conclusions. • Describe different ML algorithms (Linear Regression, Logistic Regression, Decision Trees, Clustering) and their applications with examples. • In a lab session, students analyze unstructured data using text mining techniques, applying theory learned to extract insights from real-world data.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
215624	**Data Mining with Analytics –Lab** **Major(Core) Practical**		**2**
	Course Outcomes: **Learners will be able to:** • Understand the concept of dimensionality reduction and its applications. • Comprehend the principles of association rule mining. • Implement the Apriori algorithm to mine association rules • Grasp the concept of collaborative filtering for recommendation systems • Understand the importance of TF-IDF in text mining and information retrieval. • Learn the process of tokenization in natural language processing • Implement bag-of-words for document representation and feature extraction.		
Module 1	**FOUNDATION OF DATA ANALYSIS**		1
	LOs: Learners will be able to • Evaluate the impact of dimensionality reduction on model performance. • Interpret and communicate the results of dimensionality reduction in a real-world context • Grasp the characteristics of time series data, including trend and seasonality. • Apply time series forecasting techniques such as moving averages and ARIMA models. • Grasp the concept of adjacency matrices in graph theory. • Apply adjacency matrices to represent and analyze relationships in graphs.	**Module Contents:** • t-Distributed Stochastic Neighbour Embedding (t-SNE) • Market Basket Analysis • Support, Confidence, and Lift in Association Rules • Item-Based Collaborative Filtering • Evaluation Metrics for Recommender Systems • Evaluation Metrics for Time Series Forecasting • Connectivity and Paths in Graphs • Tokenization Techniques: Word, Sentence, and Sub-word • N-grams and Extensions to Bag of Words	
Module 2	**TEXT ANALYSIS**		1
	LOs: Learners will be able to • Apply moving averages and exponential smoothing techniques to time series data. • Demonstrate an understanding of how smoothing methods reduce noise and highlight trends. • Evaluate the impact of smoothing on the accuracy of data analysis. • Apply smoothing methods to real-world datasets, such as	**Module Contents:** • Concepts of nodes, edges, and graphs. • Types of graphs: Directed and undirected. • Basics of text data and its challenges. • Importance of text representation in user-centric applications. • Part-of-speech tagging and named entity recognition. • Tokenization in text analysis.	

	financial data or sensor readings. • Apply adjacency matrices to different types of graphs, such as directed and weighted graphs • Analyze the connectivity and paths in graphs represented by adjacency matrices. • Solve practical problems using adjacency matrices, such as finding connected components.	• Implementing different tokenization techniques. • Solving problems related to custom tokenization. • Basics of bag-of-words model. • Extensions to bag-of-words, including n-grams. • Creating bag-of-words representations for documents. • Exploring applications in text classification.	
Assignments/ Activities			
	These assignments aim to cover practical application and critical thinking. • Apply PCA to a dataset and visualize the reduced dimensions. Analyze the explained variance for different components. • Use Apriori algorithm on a transaction dataset (e.g., retail transactions) and extract meaningful association rules. Evaluate the rules based on support, confidence, and lift. • Forecast future values of a time series using a moving average or ARIMA model. Evaluate the accuracy of the forecast using metrics like MAE or RMSE. • Represent a simple graph using an adjacency matrix and perform graph traversal algorithms (e.g., depth-first search) on it. • Implement a custom tokenizer for a specific language or domain, considering challenges like handling punctuation and special characters. • Tokenize a set of text documents using existing NLP libraries and compare the results with different tokenization techniques. • Create a bag-of-words representation for a set of documents. Apply this representation to perform text classification.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
215625	**APPLIED ARTIFICIAL INTELLIGENCE: LAB** **Major (core) Practical**		**2**
	Course Outcomes: **Learners will be able to:** • Understand the principles of Exploratory Data Analysis (EDA) and its significance in data analysis. • Implement univariate and bivariate analysis techniques to explore and understand dataset characteristics. • Demonstrate proficiency in handling missing data through appropriate imputation methods. • Detect and effectively manage outliers in a dataset. • Apply encoding techniques for handling categorical data in the context of data pre-processing.		
Module 1	**Exploratory Data Analysis (EDA)& Data Pre-processing, Expert System, Feature Engineering, Reinforcement Learning**		1
	LOs: Learners will be able to • Understand the importance of EDA in the data analysis process. • Apply univariate and bivariate analysis techniques to gain insights into dataset characteristics. • Implement outlier detection methods to identify and manage anomalous data points. • Demonstrate proficiency in handling missing data through appropriate imputation techniques. • Apply encoding methods for categorical data to prepare datasets for machine learning. • Grasp the fundamental concepts and principles of expert systems. • Develop the skills to design and implement an expert system using appropriate knowledge representation techniques. • Evaluate and enhance the expert system's decision-making capabilities through iterative refinement. • Understand the concept of fuzzy sets and their applications. • Implement various operations on fuzzy sets using Python	**Module Contents:** • Basics of Python programming language • Data types, variables, and operators • Control structures (if statements, loops) • Overview of EDA and its significance • Hands-on exercise: Implementing EDA using Pandas and Matplotlib • Outlier detection techniques • Handling missing data: Imputation methods • Encoding categorical data: One-Hot Encoding, Label Encoding • Univariate and bivariate analysis techniques • Understanding expert systems and their applications • Knowledge representation techniques • Rule-based systems • Practical exercise: Design and implement a simple expert system • Introduction to fuzzy sets and fuzzy logic • Python libraries for fuzzy logic operations • Hands-on exercise: Performing different operations on a fuzzy set • Importance of feature	

	programming. • Analyze the results of fuzzy set operations and interpret their significance. • Gain a comprehensive understanding of feature engineering and its role in model improvement. • Apply feature engineering techniques to enhance the predictive power of a dataset. • Implement feature transformation methods for dimensionality reduction and improved model performance. • Understand the principles of reinforcement learning and intelligent agent development. • Develop intelligent agents using reinforcement learning algorithms. • Evaluate and optimize the performance of intelligent agents through iterative learning processes.	engineering in machine learning • Techniques for feature engineering • Feature transformation methods: Scaling, Normalization • Practical exercise: Implementing feature engineering on a dataset	
Module 2	**Logic gates(XOR gate) in Neural Network, Chatbot, Tic-Tac-Toe game, ANN, Genetic Algorithm**		1
	LOs: Learners will be able to • Understand the concept of logic gates and their integration into neural networks. • Implement XOR gate functionality using a neural network. • Analyze and interpret the impact of different network architectures on logic gate performance. • Develop foundational knowledge in natural language processing. • Implement a simple chatbot in Python with basic conversational abilities. • Customize and extend chatbot functionality based on user interactions. • Implement a functional Tic-Tac-Toe game using Python. • Demonstrate proficiency in handling user inputs and managing game states. • Implement strategies for an	**Module Contents:** • Basics of reinforcement learning • Creating intelligent agents • Q-learning and policy-based methods • Hands-on exercise: Developing intelligent agents • Neural networks and their applications • Basics of logic gates and their representation in neural networks • Practical exercise: Implementing XOR gate functionality in a neural network • Introduction to natural language processing • Design principles for chatbots • Hands-on exercise: Writing a Python program for a simple chatbot • Basics of game development in Python • Designing game logic • Hands-on exercise: Implementing a functional Tic-Tac-Toe game • Case Study on Artificial Neural	

	intelligent computer opponent. • Analyze and understand the practical applications of artificial neural networks. • Evaluate the performance of ANN models in solving specific problems through a case study. • Communicate findings effectively and draw conclusions based on the case study. • Grasp the principles and applications of genetic algorithms. • Apply genetic algorithm techniques to solve optimization problems in a real-world case study. • Evaluate and compare the effectiveness of genetic algorithms against other optimization methods in the given context.	Networks (ANN) • Application of ANN in a specific problem domain • Analysis and interpretation of results • Case Study on Genetic Algorithm • Real-world optimization problem • Evaluation of genetic algorithm performance	
Assignments/ Activities			
	Here are assignment/activity ideas for each of the mentioned topics: • Provide a dataset and ask students to perform EDA and data pre-processing. Include tasks such as outlier detection, handling missing data, and encoding categorical variables. • Task students with designing an expert system for a specific domain or problem. They should implement knowledge representation and decision-making components. • Assign different fuzzy set operations (union, intersection, complement, etc.) to students. They should implement these operations in Python and demonstrate their understanding. • Provide a dataset and instruct students to perform feature engineering and transformation. They should experiment with techniques like scaling, normalization, and creating new features. • Task students with implementing a simple reinforcement learning agent for a game or problem. They should experiment with different algorithms and parameters. • Instruct students to implement a neural network that can perform XOR gate functionality. They should experiment with different architectures and activation functions. • Task students with creating a basic chatbot using Python. They should focus on handling user inputs, generating responses, and incorporating simple conversation flows. • Ask students to implement a functional Tic-Tac-Toe game in Python. They should incorporate user input handling, game logic, and a win/lose condition. • Assign a case study involving the application of ANN in a specific industry or problem. Students should analyze the dataset, design, and train the network, and interpret the results.		

	• Provide a real-world problem that requires optimization and ask students to solve it using a genetic algorithm. They should experiment with different parameters and settings.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
225611	**Ethical Hacking** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand the core concepts related to malware, hardware and software vulnerabilities and their causes. • Understand ethics behind hacking and vulnerability disclosure. • Appreciate the Cyber Laws and impact of hacking. • Exploit the vulnerabilities related to computer system and networks using state of the art tools and technologies.		
Module 1	**Introduction to Ethical Disclosure:**		1
	LOs: Learners will be able to • Define and understand fundamental concept of Ethical hacking. • Understand ethics of hacking • Comprehend legal surrounding of ethical hacking. • Apply protocols for proper and ethical disclosure of security vulnerabilities.	**Module Contents:** • Ethics of Ethical Hacking, Ethical Hacking And the legal system, Proper and Ethical Disclosure	
Module 2	**Penetration Testing and Tools**		1
	LOs: Learners will be able to • Used Penetration testing tool efficiently. • Develop skills using Metasploit which is penetration testing tool with demonstration of BackTrack.	**Module Contents:** • Using Metasploit, Using BackTrack Live CDLinux Distribution.	
Module 3	**Vulnerability Analysis and Client-side browser exploits**		1
	LOs: • Understand and differentiate different vulnerability analysis technique. • Develop expertise in advanced reverse engineering methodologies • Apply Sulley's Intelligent fuzzing technique to find exploit weaknesses.	**Module Contents:** • **Vulnerability Analysis:** Passive Analysis, Advanced Static Analysis with IDA Pro, Advanced Reverse Engineering. • **Client-side browser exploits:** Exploiting Windows Access Control Model for Local Elevation Privilege, Intelligent Fuzzing with Sulley, From Vulnerability to Exploit.	

Module 4	Malware Analysis		1
	LOs: Learners will be able to • Understand Fundamentals of malware • Define the Hacking malware. • Describe way to collect and analyse the malware • Illustrate the case study	**Module Contents:** • **Malware Analysis:** Collecting Malware and Initial Analysis, Hacking Malware. • Case study of vulnerability of cloud platforms and mobile platforms & devices	
Assignments/ Activities towards CCE			
	• Consider given/ real-time security scenario. • Apply the penetration testing using penetration tool • Perform vulnerability analysis on scenario. • Check for client side browsing exploits using Sulley's Intelligent fuzzing. • Perform malware analysis by collecting and analysing malware. • Explore case study.		

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Erickson, Jon. *Hacking: The Art of Exploitation.* SPD.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
225612	**PROJECT MANAGEMENT** **Elective Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding Project Management Fundamental concepts. • Develop skills in creating project plans, Identify, assess, and manage project risks by developing risk management plans. • Explore software testing methodologies and quality assurance practices to ensure the reliability and functionality of software deliverables. • Define and implement configuration identification processes and version control systems to manage changes and track the evolution of software throughout the project.		
Module 1	**Project Management Framework**		1
	LOs: Learners will be able to • Understanding fundamental project management concepts, including project scope and objectives. • Define different project life cycle models (e.g., Waterfall, Agile, Iterative) and understand when to apply each based on project requirements. • Identify the software scope statement for better estimates of cost and schedule.	**Module Contents:** • Overview of project Management, Project Organization, Planning a s/w project, Project management life cycle, Risk management, Identification of Risks, Risk Analysis, Risk Planning & Monitoring • S/w Project Estimation: Project Estimation , Different methods of estimation (COCOMO model, Delphi cost estimation etc.), Function point analysis	
Module 2	**Project Management Tools, Techniques and Software Management, Testing & Quality Assurance**		1
	LOs: Learners will be able to • Apply techniques for gathering, analyzing, and managing software requirements, ensuring clarity, completeness, and alignment with end users needs. • Understand the fundamentals of software testing, its goals, and its role in ensuring the quality of software products. • Understand the principles and objectives of quality assurance in software development, emphasizing prevention over detection.	**Module Contents:** • Project Management Tools & Techniques PERT & Gantt Charts, Introduction to Microsoft Project • Software Quality Management & Testing • Quality Assurance & Standards, Quality Planning, Quality control Role of testing in Software development , Testing Procedure, Defect Management	

Module 3	**Configuration Management (CM):**		1
	LOs: Learners will be able to • Define and implement configuration identification processes and version control systems to manage changes and track the evolution of software throughout the project.	**Module Contents:** • CM planning, Change Management, Version and Release Management, Configuration Management	
Module 4	**Software Team Management:**		1
	LOs: Learners will be able to • Understand role of Team and the user in various software management stages. • Analyse the Team structure, behaviour and role of team and end user.	**Module Contents:** • S/W Team Management: • Characteristics of Performance management, High performance Directive and collaborative styles, Team Structure, Team Communication, Managing customer expectations, Group Behaviour Role of User in Projects, User role in project management, User role in various stages of, S/W Development User role in System ,implementation.	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Develop a comprehensive software project proposal. The proposal should include project objectives, scope, deliverables, milestones, risks, and a preliminary project plan. • Design a quality assurance plan for a software project. They should identify key quality metrics, testing strategies, and processes for ensuring the overall quality of the software. • Assign readings or case studies that highlight project proposal, risk management plan for a given software project scenario.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
225613	**Fuzzy Logic and Neural Network** **Elective Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding Fuzzy Set membership functions, and fuzzy operations. • Understanding basic concepts of neural networks, including neurons, layers, weights, and activation functions. • Design and implement feed forward neural networks for tasks such as pattern recognition and classification. • Understand and apply the back propagation algorithm for training neural networks, including concepts like gradient descent and error minimization.		
Module 1	**FUNDAMENTALS OF FUZZY LOGIC**		1
	LOs: Learners will be able to • Define and differentiate between crisp sets and fuzzy sets, explaining the concept of membership degrees and their role in handling uncertainty. • Explore compatibility relations and their role in defining the degree to which two fuzzy sets can coexist or overlap. • Understand the concept of morphisms in fuzzy sets, exploring how transformations can be applied to fuzzy sets while preserving their structure.	**Module Contents:** • Basic concepts: fuzzy set theory-basic concept of crisp sets and fuzzy sets- complements- union intersection- combination of operation- general aggregation operations- fuzzy relations-compatibility relations-orderings-morphisms- fuzzy relational equations-fuzzy set and systems	
Module 2	**ARCHITECTURE OF NEURAL NETWORKS**		1
	LOs: Learners will be able to • Understanding Motivation for Neural Networks • Explore different types of artificial neural networks, including feedforward, recurrent, and convolutional neural networks. • Understand the typical architecture of artificial neural networks, including layers and demonstrate the ability to set and adjust weights and biases in neural networks, understanding their impact on the network's performance.	**Module Contents:** • Architectures: motivation for the development of natural networks-artificial neural networks-biological neural networks-area of applications-typical Architecture-setting weights-common activations functions Basic learning rules- Mcculloch-Pitts neuron-Architecture, algorithm, applications-single layer net for pattern classification- Biases and thresholds, linear separability - Hebb'srule- algorithm -perceptron - Convergence theorem-Delta rule	

Module 3	**BASIC NEURAL NETWORK TECHNIQUES**		1
	LOs: Learners will be able to • Define and explain the fundamental components of a neural network, including neurons, layers, weights, biases, and connections.	**Module Contents:** • Back propagation neural net: standard back propagation-architecture algorithm- derivation of learning rules number of hidden layers--associative and other neural networks- hetro associative memory neural net, auto associative net- Bidirectional associative memory-applications-Hopfield nets-Boltzman machine	
Module 4	**COMPETITIVE NEURAL NETWORKS**		1
	LOs: Learners will be able to • Understand the architecture and principles of Kohonen Self-Organizing Maps, a popular competitive learning algorithm. • Demonstrate how competitive learning can be used for feature mapping, where neural networks learn to represent high-dimensional data in a lower-dimensional space. • Understand the hierarchical structure of the Neocognitron, including the arrangement of layers and the flow of information, and how it enables the network to recognize complex patterns. • Analyse the difference of fuzzy and neural system	**Module Contents:** • Neural network based on competition: fixed weight competitive nets- Kohonenself organizing maps and applications-learning vector quantization-counter propagation nets and applications adaptive resonance theory: basic architecture and operation-architecture, algorithm, application and analysis of ART1 & ART2 • Neocognitron - Architecture, training algorithm and application-fuzzy associate memories, fuzzy system architecture- comparison of fuzzy and neural system	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • performing basic fuzzy set operations, including union, intersection, and complement, using real-world examples • implement a single-layer perceptron for a binary classification task, and analyse its performance on different datasets. • Create a feedforward neural network for a specific problem, define its architecture, and train it using backpropagation.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
225614	**Linear Algebra** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • To learn iterative techniques for solving large sparse linear systems of equations • To learn computation of eigen values, least square problems and error analysis • To learn analytical geometry concept • To learn mathematical models' theoretical concept for using it in machining learning • Explain and fluently apply fundamental linear algebraic concepts such as matrix norms, Eigen- and singular values and vectors; • Estimate stability of the solutions to linear algebraic equations and eigen value problems; recognize matrices of important special classes, such as normal, unitary and select efficient computational algorithms based on this classification		
Module 1	**Systems of Linear Equations**		1
	LOs: Learners will be able to • Gain a comprehensive understanding of the mathematical foundations, algorithms, and practical applications of machine learning • Providing a solid basis for further exploration in the field.	**Module Contents:** • System of Linear Equations, Matrices, Vector Spaces, Linear Dependence, Basis and Rank, Affine Spaces Analytic Geometry • Norms, Angles and Orthogonality, Orthonormal Basis, Orthogonal Component, Orthogonal Projections, Rotations Matrix Decomposition • Eigenvalues and Eigenvectors, Eigen Decomposition, Singular Value Decompositions Probability and Distributions • Discrete and Continuous Probabilities, Sum Rule, Product Rule and Bayes' Theorem, Gaussian Distributions	
Module 2	**Ingredients of Machine Learning**		1
	LOs: Learners will be able to • Acquire a profound understanding of the foundational elements of machine learning, encompassing tasks, models, and features crucial for problem-solving. • Demonstrate proficiency in binary	**Module Contents:** • The Ingredients of Machine Learning Tasks: The Problems that can be Solved with Machine Learning, Models: The output of Machine Learning,	

	classification and related tasks, including classification, scoring, ranking, and class probability estimation. • Extend their knowledge to encompass complex machine learning scenarios beyond binary classification, covering handling multiple classes, regression, unsupervised learning, descriptive learning, and concept learning within the hypothesis space.	Features: The Workhorses of Machine Learning • Binary Classification and Related Tasks Classification, Scoring and Ranking, Class Probability Estimation • Beyond Binary Classification Handling More than Two Classes, Regression, Unsupervised and Descriptive Learning ,Concept Learning • The Hypothesis Space, Paths through the Hypothesis Space	
Module 3	**Mathematical Models**		1
	LOs: Learners will be able to • Master tree models, including decision trees, ranking, and probability estimation trees, understanding tree learning as a variance reduction technique. • Develop proficiency in rule models, covering learning ordered and unordered rule lists, descriptive rule learning, as well as linear and probabilistic models, including the least-squares method, perceptron, support vector machines, and probabilistic models for different data types.	**Module Contents:** • Tree Models Decision Trees, Ranking and Probability Estimation Trees, Tree Learning as Variance Reduction • Rule Models Learning Ordered Rule Lists, Learning Unordered Rule Lists, Descriptive Rule Learning, First Order Rule Learning Linear Models • The Least-Squares Method, The Perceptron, Support Vector Machines, Obtaining Probabilities from Linear Classifiers, Going Beyond Linearity with Kernel Methods • Probabilistic Models The Normal Distribution and Its Geometric Interpretations, Probabilistic Models for Categorical Data, Discriminative Learning by Optimizing Conditional Likelihood, Probabilistic Models with Hidden Variables	

Module 4	**Model Ensembles**		1
	LOs: Learners will be able to • Attain expertise in various kinds of features, feature transformations, construction, and selection techniques crucial for effective machine learning. • Understand model ensembles, including bagging, random forests, boosting, and the mapping of ensemble landscapes, enhancing their ability to create robust and accurate machine learning models.	**Module Contents:** • Features Kinds of Features, Feature Transformations, Feature Construction and Selection • Model Ensembles Bagging and Random Forests, Boosting, Mapping Ensemble Landscape	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Provide diverse datasets and challenge participants to engineer features creatively to improve model performance. • Include tasks such as handling missing data, creating interaction terms, and transforming variables. • Conduct a hands-on workshop on building model ensembles like bagging, random forests, and boosting. • Allow participants to implement ensemble methods on sample datasets, compare results, and analyze the ensemble landscape. • Assign a real-world dataset and task participants with identifying and justifying feature selections for optimal model performance. • Encourage the use of techniques like recursive feature elimination and cross-validation for robust evaluations.		

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Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, 2012.

Ethem Alpaydin, "Introduction to Machine Learning", 3rd Edition, The MIT Press, 2014.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester II		
225615	**Inferential Statistics** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • To make students understand and make inferences based on relations found in the sample, to relations in the population. • For each individual statistical test students should be able to understand how it works, for what data and design it is appropriate and how results should be interpreted. • Acquire an understanding of the concepts of sampling distribution, statistical reliability and hypothesis testing, as well as the principles and procedures of the various tests of significance. • Write python program to carry out data analyses • Interpret the output of such analysis.		
Module 1	**Probability**		1
	LOs: Learners will be able to • Develop a profound understanding of foundational probability concepts, including sample space, events, and probability calculations. • Attain proficiency in dealing with random variables, comprehending their conceptual underpinnings, and distinguishing between discrete and continuous probability distributions. • Acquire practical skills in applying conditional probability, statistical independence, and Bayes' Rule to solve complex probability problems.	**Module Contents:** • Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability, Independence, and the Product Rule, Bayes' Rule. • Random Variables and Probability Distributions: Concept of a Random Variable, Discrete Probability Distributions, Continuous Probability Distributions, Statistical Independence	
Module 2	**Mathematical Expectation**		1
	LOs: Learners will be able to • Master the calculations of mean, variance, and covariance for random variables, along with their applications in real-world scenarios. • Acquire proficiency in analyzing and applying discrete probability distributions, including the Binomial, Geometric, and Poisson distributions. • Develop the ability to utilize Chebyshev's Theorem for making robust statistical inferences and understanding data dispersion.	**Module Contents:** • Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem • Discrete Probability Distributions: Introduction and Motivation, Binomial, Distribution, Geometric Distributions and Poisson distribution	

Module 3	**Probability Distributions**		1
	LOs: Learners will be able to • Develop expertise in continuous probability distributions, including the Continuous Uniform and Normal distributions, and apply them to practical scenarios. • Master the fundamentals of sampling distributions, random sampling, and important statistics, with a focus on the Central Limit Theorem. • Gain proficiency in utilizing sampling distributions, including the t-Distribution and F-Distribution, for statistical inference and hypothesis testing.	**Module Contents:** • Continuous Probability Distributions : Continuous Uniform Distribution, Normal Distribution, Area sunder the Normal Curve, Applications of the Normal Distribution, Normal Approximation to the Binomial, Gamma and Exponential Distributions. • Fundamental Sampling Distributions: Random Sampling, Some Important Statistics, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem, Sampling Distribution of S2, t –Distribution, F-Distribution.	
Module 4	**Hypotheses Testing**		1
	LOs: Learners will be able to • Acquire a solid understanding of classical methods of estimation, covering mean, variance, and proportion estimation, as well as maximum likelihood estimation. • Develop proficiency in statistical hypothesis testing, including concepts, procedures, and tests for single and two means, single proportion, and two proportions for two samples. • Gain expertise in small sampling theory, exploring distributions such as Student's t, Chi-Square, and F, along with applications in confidence intervals and hypothesis testing. • Master the Chi-Square Test, its applications in goodness of fit, contingency tables, and correlation of attributes, enhancing skills in statistical analysis. • Explore the fundamentals of stochastic processes and Markov chains, providing insights into dynamic systems and their probabilistic behaviors.	**Module Contents:** • Estimation & Tests of Hypotheses: Introduction, Statistical Inference, Classical Methods of Estimation: • Estimating the Mean, Standard Error of a Point Estimate, Prediction Intervals, Tolerance Limits, Estimating the Variance, Estimating a Proportion for single mean, Difference between Two Means, between Two Proportions for Two Samples and Maximum Likelihood Estimation. • Statistical Hypotheses: General Concepts, Testing a Statistical Hypothesis, Tests Concerning a Single Mean, Tests on Two Means, Test on a Single Proportion, Two Samples: Tests on Two Proportions • Small Sampling Theory: Small Samples, Student's t Distribution, Confidence Intervals, Tests of Hypotheses and Significance, The Chi-Square Distribution, Confidence Intervals for Sigma , Degrees of Freedom, The F Distribution. • The Chi-Square Test: Observed and Theoretical Frequencies, Definition of chi-	

		square, Significance Tests, The Chi-Square Test for Goodness of Fit, Contingency Tables, Yates' Correction for Continuity, Simple Formulas for Computing chi-square, Coefficient of Contingency, Correlation of Attributes, Additive Property of chi-square. • Stochastic Processes and Markov Chains: Introduction to Stochastic processes-Markovprocess	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Engage participants in estimating means, variances, proportions, and implementing classical methods of estimation. • Conduct hypothesis tests for single means, two means, and single proportions, emphasizing practical interpretation. • Demonstrate the application of Student's t-distribution in small samples, constructing confidence intervals and conducting tests of hypotheses. • Guide participants through the Chi-Square test, covering goodness of fit, contingency tables, and applications in real-world scenarios. • Introduce participants to stochastic processes, specifically Markov processes, through hands-on examples. • Encourage participants to model and analyze real-world situations using Markov chains.	

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Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers, Keying Ye, "Probability & Statistics for Engineers & Scientists," 9th Edition, Pearson Publishers.

S C Gupta and V K Kapoor, "Fundamentals of Mathematical Statistics," Khanna Publications.

S. D. Sharma, "Operations Research," Kedarnath and Ramnath Publishers, Meerut, Delhi.

T.T. Soong, "Fundamentals of Probability and Statistics for Engineers," John n Wiley & Sons Ltd, 2004.

Sheldon M Ross, "Probability and Statistics for Engineers and Scientists," Academic Press.

Exit:
On completion of 44 credits, if student wish to exit the Programme, then, student will get Post Graduate Diploma in Data Science (PGD in DS)

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
315611	**BIG DATA ANALYTICS** **Major (Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Learn, understand, and practice big data analytics approaches, which include the conceptualization and summarization of big data and machine learning, and big data computing technologies. • Ability to identify the characteristics of datasets and compare the trivial data and big data for various applications. • Ability to solve problems associated with batch learning and online learning, and the big data characteristics such as high dimensionality, dynamically growing data and in particular scalability issues.		
Module 1	**INTRODUCTION**		1
	LOs: Learners will be able to • Explore the fundamental concepts of Big Data, including its characteristics and types, providing a foundational understanding of the scale and complexity of modern data challenges. • Compare and contrast traditional and Big Data approaches, delving into the diverse technologies available for processing and analyzing large datasets. • Examine the infrastructure requirements for effective Big Data handling, emphasizing the role of data analytics in extracting valuable insights. • Investigate the challenges inherent in Big Data, ranging from volume to velocity and variety.	**Module Contents:** • Introduction to Big Data, Big Data Characteristics, Types of Big Data • Traditional Versus Big Data Approach, Technologies Available for Big Data • Infrastructure for Big Data, Use of Data Analytics, Big Data Challenges, Desired Properties of a Big Data System, Case Study of Big Data Solutions	
Module 2	**Analytical Theory and Methods**		1
	LOs: Learners will be able to • Acquire expertise in clustering algorithms, association rules, and the	**Module Contents:** • Clustering and Associated Algorithms, Association Rules, Apriori Algorithm, Candidate Rules	

	Apriori Algorithm for effective pattern recognition in diverse datasets. • Apply association rules to real-world scenarios, mastering validation and testing for robust and reliable models. • Develop proficiency in both linear and logistic regression models, gaining the skills to implement and interpret regression analyses. • Explore additional regression models, enhancing your analytical capabilities for varied data-driven challenges.	• Applications of Association Rules, Validation and Testing, Diagnostics, Regression, Linear Regression, Logistic Regression, Additional Regression Models	
Module 3	**Hadoop**		1
	LOs: Learners will be able to • Gain a foundational understanding of Hadoop, covering its definition, core components, and the role of operating systems in Big Data processing. • Develop proficiency in Hadoop architecture, ecosystem components, and associated technologies like Hive. Explore the limitations of Hadoop and delve into practical applications, with a focus on recommendation systems.	**Module Contents:** • Introduction, What is Hadoop?, Core Hadoop Components, Operating System for Big Data • Concepts, Hadoop Architecture, Hadoop Ecosystem, Hive, , Hadoop Limitations , Recommendation Systems.	
Module 4	**NoSQL**		1
	LOs: Learners will be able to • Develop a thorough comprehension of NoSQL, including its definition, business drivers, case studies, and various data architectural patterns, enabling informed decision-making in diverse data management scenarios.	**Module Contents:** • What is NoSQL?, NoSQL Business Drivers, NoSQL Case Studies, NoSQL Data Architectural Patterns • Variations of NoSQL Architectural Patterns, Using NoSQL to Manage Big Data • Map Reduce: MapReduce and The New Software Stack, MapReduce, Algorithms Using MapReduce	

	• Gain practical skills in MapReduce, exploring its role in the new software stack, and understanding how to implement algorithms using MapReduce for efficient big data processing.		
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Choose a Big Data case study from a diverse industry. • Evaluate the traditional and Big Data approaches employed in the case. • Identify the types of Big Data involved, considering their characteristics. • Assess the infrastructure, data analytics tools, and challenges faced. • Discuss how desired properties of a Big Data system were achieved. • Present findings and recommendations in a comprehensive report. • Collect a dataset with relevant variables for regression analysis. • Perform linear regression, logistic regression, and an additional regression model. • Validate and test the models, interpreting results and addressing challenges. • Create a detailed report discussing the practical applications of regression in predictive modeling. • Reflect on limitations encountered during the analysis and propose potential improvements.		

Bibliography:

Shankarmani, Radha. *Big Data Analytics.* Wiley, 2016.

Chellappan, Subhashini, and Acharya, Seema. *Big Data and Analytics.* Wiley, 2015.

Prajapati, Vignesh. *Big Data Analytics with R and Hadoop.* Pack Publishing, 2013.

Dasgupta, Nataraj. *Practical Big Data Analytics.* Pack Publishing, 2018.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
315612	**Machine Learning** **Major (Core)**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding Human learning aspects. • Understanding primitives in learning process by computer. • Understanding nature of problems solved with Machine Learning		
Module 1	**Introduction**		1
	LOs: Learners will be able to • Gain a profound knowledge of machine learning principles, distinguishing between learning and designing, training and testing, and recognizing the characteristics of various machine learning tasks, spanning both predictive and descriptive domains. • Develop expertise in diverse machine learning models, including geometric, logical, and probabilistic models. Learn feature engineering techniques, encompassing feature types, construction, transformation, and selection for effective model development.	**Module Contents:** • Machine learning, Examples of Machine Learning Problems, Structure of Learning, learning versus Designing, Training versus Testing, Characteristics of Machine learning tasks, Predictive and descriptive tasks, • **Machine learning Models**: Geometric Models, Logical Models, Probabilistic Models. • **Features:** Feature types, Feature Construction and Transformation, Feature Selection.	
Module 2	**Classification and Regression**		1
	LOs: Learners will be able to • Acquire proficiency in assessing binary and multiclass classification performance, including class probability estimation. • Develop a deep understanding of regression performance	**Module Contents:** • Binary Classification-Assessing Classification performance, Class probability Estimation Assessing class probability Estimates, Multiclass Classification. • **Regression:** Assessing performance of Regression-Error measures, Overfitting-	

	assessment, exploring error measures, recognizing catalysts for overfitting, and delving into the theory of hypothesis in the context of regression modeling.	Catalysts for Overfitting, Polynomial Regression. • Theory of hypothesis.	
Module 3	**Linear and Tree based Models**		1
	LOs: Learners will be able to • Attain expertise in linear models, encompassing the Least Squares method, Multivariate Linear Regression, Regularized Regression, Logistic Regression, and Support Vector Machines (SVM). • Develop a deep understanding of tree-based models, including Decision Trees, Regression Trees, and Clustering Trees.	**Module Contents:** • **Linear Models:** Least Squares method, Multivariate Linear Regression, Regularized Regression, Bias/Variance Trade-off, Dimension Reduction Logistic Regression, Gradient Descent, Perceptron, Support Vector Machines SVM, Soft Margin SVM, Time Series Analysis, Forecasting. • **Tree Based Models:** Decision Trees, Regression trees, Clustering Trees.	
Module 4	**Logic and Rule based models**		1
	LOs: Learners will be able to • Develop a comprehensive understanding of logic-based, algebraic, distance-based, rule-based models, and ensemble learning techniques, spanning bagging, boosting, online learning, deep learning, and reinforcement learning.	**Module Contents:** • **Logic Based and Algebraic Model:** Distance Based Models: Neighbours and Examples, Nearest Neighbours Classification, Distance based clustering K-means Algorithm, Hierarchical clustering, • **Rule Based Models**: Association rule mining. • **Ensemble Learning:** Introduction to Ensemble Learning, Bagging and Boosting, Online learning and Sequence Prediction, Deep Learning, Reinforcement Learning.	
Assignments/ Activities towards CCE			
	• Select a dataset suitable for both classification and regression tasks.		

	• Implement and assess binary and multiclass classification models, as well as regression models. Present findings in a comprehensive report, discussing challenges and theoretical aspects. • Implement models on datasets with diverse characteristics. • Compare model performances and discuss the suitability of different models for various data types and problem domains. Present findings in a visual and written format.	

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Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification (John Wiley & Sons)

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
315615	**BUSINESS INTELLIGENCE** **Major (Core) Theory**		**2**
	Course Outcomes: **Learners will be able to:** • To give an overview of significance of Business Intelligence as subject • To understand the traditional versus the modern methods in Data Analytics • To understand various mathematical models, classification and clustering methods in Data Analytics in Business Intelligence • To understand the role of Decision Support System, Artificial Intelligence, Expert , Knowledge Management and Expert Systems which support the Business Intelligence Systems • The ability to implement modern techniques in data analytics and its implementations in business intelligence. • The ability to use various numerical and mathematical models to classify the data from the business perspective. • The ability to use DSS , AI , Expert Systems and KMS for enhancing the business.		
Module 1	**Introduction to Business Intelligence and Decision Making**		1
	LOs: Learners will be able to • Develop comprehensive proficiency in Business Intelligence and Decision Support Systems by understanding their introduction, the significance of timely decisions, the role of mathematical models, data preparation techniques, and the development of decision support systems.	**Module Contents:** • **Business Intelligence:** Introduction to Business Intelligence, Significance of Effective and timely decisions in Business, The role of mathematical models, Business Intelligence architectures, Ethics and Business Intelligence • **Data Preparation:** Representation of input data, Data validation, Data transformation, Data reduction and data mining process, Analysis methodologies • **Mathematical models for decision making**: Structure of mathematical models, Development of a model, Classes of models • **Decision Support System:** Definition of system, Representation of the decision-making process, Evolution of information systems, Definition of decision support system, Development of a decision support system	

Module 2	**Business Intelligence Model and Knowledge Management**		1
	LOs: Learners will be able to • Achieve advanced proficiency in business intelligence applications, including marketing and logistic models, master efficiency analysis through data envelopment techniques, and develop comprehensive knowledge management skills covering organizational learning, IT integration, and system implementation.	**Module Contents:** • **Business intelligence applications:** **Marketing models:** Relational marketing, Sales force management, **Logistic and production models:** Supply chain optimization, Optimization models for logistics planning, Revenue management systems • **Data envelopment analysis:** Efficiency measures, Efficient frontier, The CCR model, Identification of good operating practices • **Knowledge Management:** Introduction to Knowledge Management, Organizational Learning and Transformation, Knowledge Management Activities, Approaches to Knowledge Management, Information Technology (IT) In Knowledge Management, Knowledge Management Systems Implementation, Roles of People in Knowledge Management.	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Develop a comprehensive business intelligence system, addressing the significance of timely decision-making and incorporating ethical considerations. • Implement mathematical models for decision-making, focusing on the structure, development, and classification of models within a decision support system. • Apply business intelligence to real-world scenarios by implementing marketing models (e.g., relational marketing, sales force management) and logistic and production models (e.g., supply chain optimization, revenue management systems). • Explore efficiency measures through data envelopment analysis and gain practical insights into knowledge management, including organizational learning, IT integration, and system implementation.		

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Vercellis, Carlo. *Business Intelligence: Data Mining and Optimization for Decision Making.* Wiley Publications, First Edition, 2009.

Turban, Efraim; Sharda, Ramesh; Delen, Dursun. *Decision Support and Business Intelligence Systems.* Pearson Publications, Ninth Edition, 2011.

Grossmann, W.; Rinderle-Ma, S. *Fundamentals of Business Intelligence.* Springer Publications, First Edition, 2015.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
315623	**Big Data Analytics Lab: Practical** **Major (Core)**		**2**
	Course Outcomes: **Learners will be able to:** • Master the installation and practical use of PySpark for linear and logistic regression, showcasing hands-on expertise in big data analytics. • Demonstrate advanced skills in graphical data processing, Hive database management, window functions, and time series analysis using PySpark, emphasizing practical applications in real-world scenarios.		
Module 1	**Introduction to Hadoop and Pyspark**		1
	LOs: Learners will be able to • Achieve hands-on expertise in Hadoop and PySpark by defining installation steps, and demonstrate practical skills in performing linear and logistic regression, as well as MapReduce programming for word count problems using PySpark.	**Module Contents:** • Define steps to install hadoop and pyspark • Practical to perform linear regression using pyspark • Practical to perform logistic regression using Pyspark • Practical to perform map reduce program for word count problem.	
Module 2	**Implementation using Pyspark**		1
	LOs: Learners will be able to • Attain advanced data processing skills with PySpark, encompassing the creation and access of graphical data, structured database management using Hive, implementation of window functions, and practical applications in Time Series Analysis and Aggregate functions.	**Module Contents:** • Create graphical data and access the graphical data using spark • Practical to use hive to create and store structured databases • Practical to perform window function using Pyspark. • Practical to perform Times Series Analysis using Pyspark • Practical to perform Aggregate function using Pyspark.	
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	• Document the installation steps for Hadoop and PySpark, providing a comprehensive guide. • Implement linear regression and logistic regression using PySpark on a given dataset, presenting the analysis and insights. • Provide instructions for creating graphical data and accessing it with Spark. • Utilize Hive to establish a structured database, demonstrating proficiency in data storage and retrieval operations.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
315624	**Machine Learning Lab: Practical** **Major (Core)**		**2**
	Course Outcomes: **Learners will be able to:** • Proficiently handle and analyze diverse datasets using GitHub • Execute Exploratory Data Analysis (EDA) and Data Pre-processing techniques, implement Linear and Logistic Regression, and demonstrate practical skills in applying machine learning algorithms such as Decision Trees, Support Vector Machines (SVM), K-Nearest Neighbours (KNN), Time Series Forecasting, and either Recommendation Systems or Random Forest • Showcasing versatile applications in statistical and machine learning domains.		
Module 1	**EDA**		1
	LOs: Learners will be able to • Establish and utilize a GitHub account for collaborative data work, and demonstrate the ability to load diverse data formats for statistical summarization. • Master practical implementation of Exploratory Data Analysis (EDA), Data Pre-processing, and regression modeling with Linear and Logistic Regression, showcasing applied skills in data analytics.	**Module Contents:** • Setup Github Account, loading data from different source files formats (csv, excel) and summarizing data with statistics. • Practical to implement Exploratory Data Analysis (EDA)& Data Pre-processing (Outlier Detection, Handling Missing Data, Encoding Categorical Data) • Practical to implement Linear Regression (Single/Multiple) • Practical to implement Logistic Regression	
Module 2	**Implementation of ML algorithm**		1
	LOs: Learners will be able to • Demonstrate practical competence in implementing Decision Tree, Support Vector Machine (SVM), and K-Nearest Neighbours (KNN) algorithms, showcasing versatility in classification and clustering tasks. • Apply Time Series Forecasting techniques, highlighting proficiency in predictive modeling for sequential data. • Showcase practical skills in	**Module Contents:** • Practical to implement Decision Tree Algorithm • Practical to implement Support Vector Machine (SVM) Algorithm • Practical to implement K-Nearest Neighbours KNN Algorithm • Practical to implement Time Series Forecasting • Practical to implement Recommendation Systems or Practical to implement Random Forest Algorithm	

	either developing Recommendation Systems or implementing the Random Forest Algorithm, demonstrating a comprehensive understanding of diverse machine learning applications.		
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	• Implement Decision Tree, SVM, KNN, Time Series Forecasting, and either Recommendation Systems or Random Forest on diverse datasets. • Evaluate each algorithm's performance, discuss their practical applications, and integrate them into a comprehensive project, showcasing a holistic understanding of machine learning applications.		

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Kevin Murphy, Machine Learning: A Probabilistic Perspective, MIT Press, 2012

Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer 2009

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Tom Mitchell. Machine Learning (McGraw Hill) , First Edition

Richard O. Duda, Peter E. Hart, David G. Stork. Pattern Classification (John Wiley & Sons)

Ethern Alpaydin, Introduction to Machine Learning, MIT Press, 3rd Edition.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
325611	**BLOCK CHAIN** **Major (Elective) Theory**		**3**
	Course Outcomes: **Learners will be able to:** • Understanding of Block Chain Concepts. • Including its decentralized nature, distributed ledger, and cryptographic security features. • Understand the historical context and evolution of blockchain technology, including the development of the first blockchain • Explore the Nakamoto consensus and different consensus algorithms. • Explore the concepts of interoperability and portability in Hyperledger Fabric. • Understand the concept of sharding in blockchain.		
Module 1	**Fundamentals of Blockchain**		1
	LOs: Learners will be able to • Understand the principles of distributed databases, including their architecture, advantages, and challenges. Learn how to design and manage data across multiple nodes in a network. • Explore the complexities of consensus in distributed systems when some nodes may provide conflicting or malicious information. Understand the significance of Byzantine fault tolerance in distributed systems. • Understand the concept of ASIC resistance in the context of crypto-currencies. Explore the motivations and implications of designing systems to resist mining centralization through specialized hardware. • Gain a comprehensive understanding of cryptography principles, including confidentiality, integrity, and authenticity. Learn the applications and functions of hash functions, digital signatures (specifically ECDSA), memory-hard algorithms, and zero	**Module Contents:** • Distributed Database, Two General Problem, Byzantine General problem and Fault Tolerance, Hadoop Distributed File System, Distributed Hash Table, ASIC resistance, Turing Complete. • Cryptography: Hash function, Digital Signature - ECDSA, Memory Hard Algorithm, Zero Knowledge Proof.	

	knowledge proofs.		
Module 2	**Blockchain , Distributed Consensus:**		1
	LOs: Learners will be able to • Understand the fundamental concepts of blockchain, including its decentralized nature, distributed ledger, and cryptographic security features. • Gain an understanding of the structure and operation of a blockchain network, including nodes, peers, and the peer-to-peer communication model. • Differentiate between private and public blockchains, understanding their use cases, access control, and levels of decentralization. • Explore the Nakamoto consensus and different consensus algorithms such as Proof of Work, Proof of Stake, and Proof of Burn, understanding their strengths and weaknesses.	**Module Contents:** • Introduction, Advantage over conventional distributed database, Blockchain Network, Mining Mechanism, Distributed Consensus, Merkle Patricia Tree, Gas Limit, Transactions and Fee, Anonymity, Reward, Chain Policy, Life of Blockchain application, Soft & Hard Fork, Private and Public blockchain. • Nakamoto consensus, Proof of Work, Proof of Stake, Proof of Burn, Difficulty Level, Sybil Attack, Energy utilization and alternate.	
Module 3	**Cryptocurrency , Cryptocurrency Regulation:**		1
	LOs: Learners will be able to • Understand the historical context and evolution of blockchain technology, including the development of the first blockchain in the context of Bitcoin. • Explore the construction of the Ethereum blockchain, learn about the Decentralized Autonomous Organization (DAO), and understand the concept and implementation of smart contracts.	**Module Contents:** • History, Distributed Ledger, Bitcoin protocols - Mining strategy and rewards, Ethereum - Construction, DAO, Smart Contract, GHOST, Vulnerability, Attacks, Sidechain, Namecoin. • Stakeholders, Roots of Bit coin, Legal Aspects-Crypto currency Exchange, Black Market and Global Economy. Applications: Internet of Things, Medical Record Management System, Domain Name Service and future of Blockchain.	
Module 4	**Hyperledger , Scalability and other challenges :**		1
	LOs: Learners will be able to • Understand Hyperledger as a blockchain protocol, including its reference architecture, design goals, and the modular approach it adopts.	**Module Contents:** • Hyperledger as a protocol :The reference architecture Requirements and design goals of Hyperledger Fabric: The modular approach	

	• Explore the features of Hyperledger Fabric, such as its modular architecture, privacy and confidentiality mechanisms, scalability considerations, deterministic transactions, and identity management. • Explore the scalability challenges in blockchain networks and understand how Hyperledger Fabric addresses scalability concerns in the network, consensus, storage, and view planes. • Explore the concepts of interoperability and portability in Hyperledger Fabric, understanding how it facilitates integration with other systems and ensures the portability of applications. • Understand the concept of sharding in blockchain networks, and how it enables the parallel processing of transactions to improve scalability.	Privacy and confidentiality, Scalability, Deterministic transactions Identity, Auditability Interoperability Portability Rich data queries Fabric Hyperledger Fabric Membership services Blockchain services Consensus services Distributed ledger ,The peer to peer protocol Ledger storage Chaincode services ,Components of the fabric • Scalability and Other Challenges: Scalability Network plane ,Consensus plane, Storage plane View plane ,Block size increase ,Block interval reduction Invertible Bloom, Lookup Tables Sharding State channels Private blockchain, Proof of Stake Sidechains Subchains Tree chains (trees) Block propagation Bitcoin-NG, Plasma ,Privacy Indistinguishability Obfuscation Homomorphic encryption ,Zero-Knowledge Proofs State channels Secure multiparty computation Usage of hardware to provide confidentiality Coin Join Confidential transactions, Mimble Wimble Security Smart contract security Formal verification and analysis Oyente tool	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Research and write a comprehensive essay or create a presentation that explains the fundamental concepts of blockchain, highlighting its decentralized nature, the role of a distributed ledger, and the cryptographic security features that contribute to its integrity. • Create a timeline or infographic that visually represents the historical evolution of blockchain technology. Include key milestones, developments, and influential figures in the field. • Write a research paper or prepare a presentation that delves into the concepts of interoperability and portability within Hyperledger Fabric. • Design a workshop or hands-on exercise where participants simulate the sharding process in a blockchain network. Document the findings and insights.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
325612	**GIS AND REMOTE SENSING** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding Fundamentals, Technical Skills, Data Acquisition and Management. • Spatial Analysis, Mapping and Visualization, Remote Sensing Applications, Integration of Technologies • Problem Solving, Communication Skills**.**		
Module 1	**Fundamentals of GIS**		1
	LOs: Learners will be able to • Define GIS (Geographic Information System), Understand Components of GIS, Comprehend Spatial Data, Understand Characteristics of Spatial Data • Analyze Spatial Data Maps, Attribute Data Management - Database Data Model, GIS Applications, Developments in Database for GIS.	**Module Contents:** • Defining GIS, components of GIS, spatial data, spatial data-maps, characteristics, spatial data modeling, attribute data management-database data model, GIS applications and developments in database.	
Module 2	**Input-Output and Data Analysis in GIS**		1
	LOs: Learners will be able to • Data Input and Editing, Data Analysis • Analytical Modeling in GIS, Output from GIS.	**Module Contents:** • Data input and editing– methods, editing, integration, Data analysis-measurements, queries, reclassification, buffering, map overlay, interpolation, analysis of surfaces, network analysis, spatial analysis, Analytical modeling in GIS-physical, environment and human processes, output from GIS – maps, non-cartographic output, spatial multimedia, decision support.	
Module 3	**Issues in GIS:**		1
	LOs: Learners will be able to • Development of Computer Methods, Human and Organizational Issues in GIS, GIS Data Quality and Error Analysis, GIS Project Design and Management	**Module Contents:** • Development of computer methods for spatial data, Issues in GIS- data quality and errors, sources of errors, human and organizational issues, GIS project design and	

	• Project Implementation and Evaluation, Understanding the Future of GIS, Internet Resources for GIS, Communication Skills.	management–problem identification, designing a data model, project management, Implementation, evaluation, the future of GIS, Internet resources of GIS.	
Module 4	Remote Sensing, Global Positioning Systems (GPS)		1
	LOs: Learners will be able to • Principles of Remote Sensing, Remote Sensing System Classification, Imaging Characteristics, Extraction of Information from Images, Integration of Remote Sensing and GIS • Introduction to GPS, Accuracy of GPS, Differential GPS, Applications of GPS, Integration of GIS and GPS.	**Module Contents:** • Principles of remote sensing, remote sensing system-classification, Imaging, characteristics, extraction of information from images–metric and thematic, Integration of RS and GIS. • Introduction to GPS, Accuracy of GPS, Differential GPS, Applications of GPS, Integration of GIS and GPS.	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Discuss the importance of metadata in data warehousing, to create a metadata management plan for a given data warehouse, outlining how metadata will be collected, stored, and utilized. • From a dataset extract relevant information, transform it according to a predefined business rule, and load it into a data warehouse. • Create a set of business queries related to a hypothetical business problem • Find a dataset suitable for clustering analysis. then use clustering algorithms to identify natural groupings within the data and interpret the results. • web mining project (perform web scraping, and apply web mining techniques)		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
325613	**Software Testing** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand the fundamental principles and concepts of software testing, including its purpose, objectives, and the role it plays in software development. • Proficient in various test design techniques, including equivalence partitioning, boundary value analysis, decision tables, and state transition testing, enabling them to create effective test cases. • Apply various testing methods such as functional, non-functional, unit, integration, system, regression, and acceptance testing to diverse software systems. • Understand quality assurance principles and best practices, emphasizing the importance of testing in the software development lifecycle. • Understand the ethical and professional responsibilities associated with software testing.		
Module 1	**Overview of Software Testing**		1
	LOs: Learners will be able to • Gain proficiency in software testing terminologies, methodologies, and life cycles. • Comprehend the economic aspects of testing and its impact on organizational structures. • Develop skills in creating policies, test strategies, and risk management to ensure meeting customer needs. • Analyze the advantages of structured testing processes and their cost implications. • Demonstrate proficiency in the seven-step software testing process.	**Module Contents:** • Software Testing Terminology and Methodology Software Testing Terminology, Software Testing Life Cycle, Writing a Policy for Software Testing, Economics of Testing, Testing – An organizational Issue, Management Support for Software Testing, Fig. of Software Testing Methodology, Risk associated with not meeting customer needs, Developing Test Strategy • Overview of Software Testing Process Advantages of Following a Process, The Cost of Computer Testing, The Seven-Step Software Testing Process • Verification and Validation Verification and Validation (V&V) Activities, Verification, Verification of Requirements, Verification of High –level Design, Verification of Low – level Design, How to Verify Code? ,Validation	

		• Static Testing Inspections, Structured Walkthroughs, Technical Reviews.	
Module 2	**Validation and Regression Testing**		1
	LOs: Learners will be able to • Execute various validation activities including unit, integration, function, system, and acceptance testing to assess different aspects of software functionality and ensure its compliance with requirements. • Differentiate between progressive and regressive testing, comprehending the significance of regression testing in maintaining software quality. • Apply regression testing techniques to identify potential issues arising from software changes or updates, thereby ensuring the stability and reliability of the software product. • Identify the objectives of regression testing and determine appropriate instances for conducting regression tests in the software development life cycle. • Define regression test problems, select suitable types of regression testing, and utilize effective regression testing strategies to address software changes and minimize the risk of introducing new defects into the system.	**Module Contents:** • Validation Activities Unit Validation Testing, Integration Testing, Function Testing, System Testing , Acceptance Testing • Regression Testing Progressive vs. Regressive Testing, Regression Testing Produces Quality Software, Regression Testability, Objectives of Regression Testing, When is Regression Testing Done? , Regression Testing Types, Defining Regression Test Problem, Regression Testing Techniques.	
Module 3	**Testing Management and Metrics**		1
	LOs: • Establish a comprehensive understanding of test management structures, including the organization and composition of testing groups, enabling effective test planning and detailed	**Module Contents:** • Test Management Test Organization, Structure of Testing Group, Test Planning, Detailed Test Design and Test Specifications • Software Metrics Need for Software Management, Definition of Software Metrics, Classification	

	test design. • Recognize the need for software metrics and demonstrate the ability to define, classify, and apply various metrics within the software development life cycle. • Evaluate entities to be measured within software projects, particularly focusing on size metrics and their implications on software management. • Formulate measurement objectives specific to testing, identifying attributes and corresponding metrics relevant to monitoring and controlling the testing process.	of Software Metrics, Entities to be Measured, Size Metrics • Testing Metrics for Monitoring and Controlling the Testing Process Measurement Objectives for Testing, Attributes and Corresponding Metrics in Software Testing, Attributes, Estimation Models for Estimating Testing Efforts (include only topic Halstead Metrics), Test Point Analysis (TPA) – introduction only.	
Module 4	**Automation Testing Tool**		1
	LOs: Learners will be able to • Evaluate the necessity and significance of test process maturity, demonstrating the ability to measure, assess, and improve test processes within an organization using established maturity models. • Identify the rationale behind automation in testing, categorize various testing tools, and apply criteria for selecting appropriate tools while considering associated costs. • Analyze guidelines for automated testing and gain an overview of commercial testing tools, fostering the skills required for implementing automated testing effectively. • Apply agile methodologies to enhance software testing, recognizing the importance of agility, overcoming inhibitors, and implementing solutions to improve testing processes within an agile framework.	**Module Contents:** • Testing Process Maturity Models Need for Test Process Maturity, Measurement and Improvement of a Test Process, Test Process Maturity Models • Automation and Testing Tools Need for Automation, Categorization of Testing Tools, Selection of Testing Tools, Cost Incurred in Testing Tools, Guidelines for Automated Testing, Overview of Some Commercial Testing Tools Testing Object Oriented Software Object-Oriented Testing • Using Agile Methods to Improve Software Testing The importance of Agility, Building an Agile Testing Process, Agility Inhibitors, Is Improvement Necessary, Compressing Time, Challenges, Solutions , Measuring Readiness , The Seven-Step Process 4.5 Test Plan.	

Assignments/ Activities towards CCE		
	• Provide a case study of an organization's testing process and have students analyze and propose improvements based on maturity model principles. • Organize a session where students demonstrate how a specific testing tool works, highlighting its features, benefits, and practical applications. • Conduct a simulation where students participate in an agile testing environment, taking on roles (developer, tester, product owner) to experience iterative development, testing, and feedback cycles. • Provide a software scenario and ask students to create a comprehensive test plan, including test objectives, strategies, resource allocation, and metrics for evaluating test progress. • Divide students into teams, assigning each team a different validation testing type (e.g., unit, integration). They role-play scenarios to validate a software component or system.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
325614	**Data Visualization** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding basic Data Science concepts. • Learning to detect and diagnose common data issues, such as missing values, special values, outliers, inconsistencies, and localization. • Learning various Machine Learning Techniques to Predict the Data. • Understanding basic Data Science concepts. • Learning to detect and diagnose common data issues, such as missing values, special values, outliers, inconsistencies, and localization. • Learning various Machine Learning Techniques to Predict the Data.		
Module 1	**Introduction to Data &Data data transformation**		1
	LOs: Learners will be able to • proficient in defining and categorizing diverse data types, conducting Exploratory Data Analysis (EDA) within the Data Science lifecycle, mastering data collection and extraction, and applying data transformations such as dimension reduction and feature extraction for effective analysis and modeling.	**Module Contents:** • What is Data? Different kinds of data, Data Sources, Different types of data sources, • Exploratory Data Analysis (EDA), Data Science lifecycl**e**, Data Collection • Data Extraction, Data Analysis & Modelling • Data transformations :Dimension reduction, Feature extraction, Smoothing and aggregating	
Module 2	**Python concepts used in data Science**		1
	LOs: Learners will be able to • proficiently manipulate arrays using NumPy, perform mathematical operations, and manipulate shapes, while also mastering the pandas library for efficient data structure handling, data insertion, and export. Additionally, learners will acquire skills in data cleansing, including checking and filling missing data, and perform advanced data operations such as aggregations and joins.	**Module Contents:** • The World of arrays with Numpy : creating an array, Mathematical operations, Indexing and slicing, Shape manipulation. • Empowering Data analysis with pandas :the data structure of pandas, Inserting and exporting data • Data Cleansing**:** checking missing data, filling missing data, merging operations • Data Operations**:** Aggregation operations, Joins	

Module 3	**Inferential Statistics & Data Visualization**		1
	LOs: Learners will be able to • possess a solid understanding of inferential statistics, encompassing distributions, z-scores, p-values, Type 1 and Type 2 errors, confidence intervals, correlations, Chi-square distribution, and ANOVA. • Additionally, they will master data interpretation through visualization, including chart customization, creating diverse plots, styling, and effectively using visualization tools like boxplots, heatmaps, scatter plots with histograms, and bubble charts.	**Module Contents:** • Inferential Statistics**:** Various forms of distribution, z-score, p-value, Type 1 and Type 2 errors, Confidence Interval, Correlation, Chi-square distribution, ANOVA • Making Sense of Data Through Visualization: Controlling the line properties of a chart, creating multiple plots, styling your plots, Boxplots, Heatmaps, Scatter plots with histogram, Bubble charts	
Module 4	**Machine Learning basics & Generating Recommendation systems**		1
	LOs: Learners will be able to • comprehensive understanding of machine learning, covering various types such as linear regression, logistic regression, decision trees, and clustering algorithms like K-means and hierarchical clustering. • Additionally, they will be proficient in generating recommendation systems through user-based collaborative filtering, item-based collaborative filtering, and context-based filtering, with practical implementation skills demonstrated in a case study analyzing unstructured data using text mining techniques.	**Module Contents:** • Uncovering Machine Learning: Different types of Machine Learning, Linear Regression, Logistic Regression, Decision Tree, K-means Clustering, Hierarchical Clustering • Generating Recommendations Systems:User Based collaborative filtering, Item Based collaborative filtering, Context Based filtering • Case Study Theory:Analyzing Unstructured Data using Text mining techniques. (Case Study Practical Implementation to be performed in lab as part of Practical's)	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Form small teams and propose a data science project. Clearly outline the problem statement, the dataset to be used, and the goals of the project. • Specify the types of data involved, potential sources, and the relevance of the project to real-world applications. • Use EDA techniques to explore the dataset. Document the findings and insights gained from the exploration. • Apply data extraction methods, focusing on the use of NumPy and Pandas for handling arrays and data structures.		

	• Perform data cleansing operations, including checking for missing data, filling gaps, and merging datasets. • Apply inferential statistics concepts to analyze the dataset. Utilize statistical tests and visualization tools to draw meaningful conclusions. • Create visualizations showcasing distributions, correlations, and other relevant statistical insights using Matplotlib and Seaborn. • Implement machine learning algorithms such as linear regression, logistic regression, decision trees, and clustering techniques using scikit-learn. • Evaluate the performance of the models and document the results. • Implement recommendation systems, incorporating collaborative filtering and contextual filtering techniques. • Present the generated recommendations and assess the effectiveness of the system. • Each team presents their project, covering the entire data science lifecycle from problem formulation to machine learning and recommendation system implementation. • Discuss challenges faced, solutions implemented, and lessons learned.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester III		
325615	**Data Governance** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understanding basic Data Governance concepts. • Learning various Data Governance strategies and implementation. • Understanding Data Governance with Organizational Culture • Understanding Data Governance Policies and Procedures. • Enumerate the Various types of Data Governance Strategies and how to implement them. • Illustrate the Various Data Governance techniques. • Apply the various functions on data protection. • Simplify the various monitoring boundaries using Cultural Norms.		
Module 1	**Introduction to Data Governance**		1
	LOs: Learners will be able to • Understanding of data governance, including its components, significance in the modern landscape, practical examples, and the added value it brings to businesses. Additionally, • They will comprehend the essential ingredients of data governance, encompassing tools, the enterprise dictionary, and the symbiotic relationship between people and processes within the governance framework.	**Module Contents:** • **What Is Data Governance?:**What Data Governance Involves, Why Data Governance Is Becoming More Important, Examples of Data Governance in Action, The Business Value of Data Governance, Why Data Governance Is Easier in the Public Cloud. • **Ingredients of Data Governance: Tools** The Enterprise Dictionary. **Ingredients of Data Governance: People and Processes:** The People, The Process, People and Process Together	
Module 2	**Data Governance Strategies**		1
	LOs: Learners will be able to • To comprehend and articulate the intricacies of data governance throughout the data life cycle, including its phases, management, and operationalization. • Additionally, they will gain a profound understanding of data quality, recognizing its significance, integration within data governance programs, and proficiency in employing various techniques to enhance and ensure	**Module Contents:** • **Data Governance over a Data Life Cycle:** What Is a Data Life Cycle?, Phases of a Data Life Cycle, Data Life Cycle Management, Applying Governance over the Data Life Cycle, Operationalizing Data Governance. • **Improving Data Quality:** What Is Data Quality?, Why Is Data Quality Important?, Why Is Data Quality a Part of a Data Governance	

	data quality.	Program?, Techniques for Data Quality	
Module 3	**Data Governance Policies and Procedures**		1
	LOs: Learners will be able to • Skills to govern data in transit, including expertise in data transformations, lineage tracking, policy management, simulation, monitoring, and change management. Furthermore, • Tthey will acquire comprehensive knowledge of data protection, encompassing planning strategies, cloud-specific considerations, physical security measures, prevention of data exfiltration, identity and access management, and best practices to maintain agile data protection.	**Module Contents:** • **Governance of Data in Flight:** Data Transformations, Lineage, Policy Management, Simulation, Monitoring, Change Management. • **Data Protection:** Planning Protection, Data Protection in the Cloud, Physical Security, Data Exfiltration, Identity and Access Management, Keeping Data Protection Agile, Data Protection Best Practices.	
Module 4	**Data Governance and Organizational Culture**		1
	LOs: Learners will be able to • Implementing effective monitoring systems, understanding the rationale behind monitoring, defining monitoring criteria, and recognizing key considerations. Additionally, they will acquire skills in fostering a culture of data privacy and security, encompassing the importance of leadership commitment, intention, training, effective communication, and the interplay with legal and security aspects. • Learners will also be proficient in incident handling procedures and understand the critical importance of transparency in managing data-related incidents.	**Module Contents:** • **Monitoring:** What Is Monitoring?, Why Perform Monitoring?, What Should You Monitor?, What Is a Monitoring System?, Monitoring Criteria, • Important Reminders for Monitoring • **Building a Culture of Data Privacy and Security:** Data Culture: What It Is and Why It's Important, Starting at the Top—Benefits of Data Governance to the Business, Intention, Training, and Communications, Beyond Data Literacy, Maintaining Agility, Interplay with Legal and Security, • Incident Handling, Importance of Transparency	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Students analyze real-world examples of data governance implementation, identifying key elements, challenges, and business benefits. • Explore the impact of adopting data governance in public cloud environments. • Groups collaborate to design a comprehensive data governance framework, considering tools, people, and processes discussed in the modules.		

	• Emphasize the integration of an enterprise dictionary and strategies for effective data governance. • Students develop a data quality improvement plan, incorporating techniques discussed in the module and understanding the importance of data quality in governance. • Simulate data protection and security scenarios, focusing on planning, cloud considerations, physical security, access management, and incident handling. • Discuss best practices to keep data protection agile. • Each group presents their monitoring plan, highlighting the criteria, system, and important reminders discussed in the module. • Discuss building a culture of data privacy and security, emphasizing the interplay with legal and security aspects, incident handling, transparency, and the role of organizational culture.	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
415611	**Deep Learning** **Major(Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Demonstrate the ability to implement a perceptron, understanding the input features, weights, bias, and the activation function. • Understanding Deep Learning, Activation Functions, Forward Propagation • Explore convolution operations, including padding, stride, and batch processing. Implement a convolution layer and a pooling layer in TensorFlow • Explore different RNN architectures, including one-to-one, one-to-many, many-to-one, and many-to-many. Implement and train RNNs. • Understand various types of autoencoders, including standard, sparse, denoising, contractive, and variational autoencoders.		
Module 1	**Introduction to Deep Learning**		1
	LOs: Learners will be able to • Understanding how to build a perceptron involves defining the input features, weights, bias, and the activation function. • Discussing the limitations of a single-layer perceptron, such as its inability to learn non-linear relationships. • Description of the structure of artificial neural networks, including input layer, hidden layers, and output layer. • Overview of activation functions that introduce non-linearity, enabling neural networks to learn complex patterns.	**Module Contents:** • Perceptron: What is a Perceptron? Implementing perceptron, Introducing & Implementing Weights & Bias, Multilayer Perceptron, Limitations of perceptron. • Introduction to Deep Learning: What is deep learning? Biological and artificial neurons, ANN and its layers, Input layer, Hidden layer, Output layer, exploring activation functions, the sigmoid function, the tanh function, The Rectified Linear Unit function, The leaky ReLU function, The Swish function, The softmax function, Forward propagation in ANN, How does ANN learn?	
Module 2	**Convolutional Neural Networks:**		1
	LOs: Learners will be able to • Analyse how TensorFlow represents computations as directed acyclic graphs (DAGs). • Understanding the concept of sessions for executing operations in a TensorFlow graph. • Analyse General architecture of CNN Comprising convolutional layers, pooling layers, and fully connected layers • Implementing a Convolution Layer, Pooling Layer	**Module Contents:** • Getting to Know TensorFlow • What is TensorFlow? Understanding computational graphs and sessions, Sessions, Variables, constants, and placeholders, Introducing TensorBoard, Creating a name scope. • Back propagation Algorithm, Neural Network Training, • Convolutional Neural Networks: • Overall Architecture, The Convolution Layer, Issues with the Fully Connected Layer, Convolution	

		Operations, Padding, Stride, Batch Processing, The Pooling Layer, Implementing a Convolution Layer, Implementing a Pooling Layer, Implementing a CNN, Visualizing a CNN.	
Module 3	**Optimizers in DL**		1
	LOs: Learners will be able to • Understanding the basic concept of gradient descent as an optimization algorithm for minimizing the loss function during training • Introduction to adaptive learning rates based on the historical gradients of parameters. • Understanding the challenges of training RNNs and the need for handling sequential dependencies. • Explanation of backpropagation through time, the algorithm used to train RNNs by unfolding them into a computational graph over time. • Different type of RNNarchitectures	**Module Contents:** • Optimizers in DL: Gradient Descent, Stochastic Gradient Descent, Mini-Batch Gradient Descent, SGD with Momentum, AdaGrad (Adaptive Gradient Descent), RMS-Prop (Root Mean Square Propagation), AdaDelta, Adam (Adaptive Moment Estimation). • Introducing RNNs: • RNN implementation and training, Backpropagation through time, Vanishing & exploding gradients, long short-term memory LSTM, • Different types of RNN architectures: • One-to-one architecture • One-to-many architecture • Many-to-one architecture • Many-to-many architecture.	
Module 4	**Deep Unsupervised Learning**		1
	LOs: Learners will be able to • Understanding autoencoders as neural network architectures designed for unsupervised learning by encoding and decoding input data. • Generative Adversarial Networks (GANs) as a framework for training generative models through adversarial training. • Understanding scenarios of different models	**Module Contents:** • Deep Unsupervised Learning: Auto encoders (standard, sparse, denoising, contractive, etc), Variational Auto encoders, • Deep Generative Models GANS.	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Task students to build a simple neural network from scratch using Python or a framework like TensorFlow/Keras. They should train it on a dataset and analyze its performance. • Provide pre-trained neural network models and have students visualize the learned features and activations at different layers to understand how information is processed. • Assign students to create a CNN model for image classification using a		

	dataset like CIFAR-10 or MNIST. They should experiment with different architectures and hyper parameters. • Challenge students to create a GAN model capable of generating realistic images from a given dataset (e.g., faces, digits). They should evaluate the quality of generated images	

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Buduma, Nikhil, Locascio, Nicholas. *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms*. O'Reilly Media, 2017.

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
415612	**NATURAL LANGUAGE PROCESSING** **Major (Core) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • To provide understanding of Text processing for Natural Language Understanding and Natural language Generation • To provide understanding of various techniques available for natural language processing • To provide understating of Knowledge of different approaches/algorithms for carrying out NLP tasks. • Get idea about know-hows, issues and challenge in Natural Language Processing and NLP applications and their relevance in the classical and modern context. • Get understanding of Computational techniques and approaches for solving • NLP problems and develop modules for NLP tasks and tools such as Tokens, Lemmas, POS,Tagger, Chunker etc. • Introduced to various grammar formalisms and will be able to understand applications in different sectors.		
Module 1	**INTRODUCTION TO NLP**		1
	LOs: Learners will be able to • Develop an understanding of Natural Language Understanding and Natural Language Generation. • Gain practical skills in using NLTK and spaCy, and learn the fundamentals of computing with languages, including text and word processing, frequency distribution, and accessing text corpora. • Master techniques for text processing using strings, covering Unicode, regular expressions, tokenization, stemming, lemmatization, segmentation, and formatting.	**Module Contents:** • **Natural Language Processing:** What is Natural Language Understanding and Natural Language Generation, Introduction to NLTK, spaCy, Computing with Languages – Text and Words, Searching Text counting vocabulary, List , Strings , Variable, Computing frequency Distribution • **Accessing Text Corpora, Lexical Resources and Processing Raw Text:** Introduction to Corpora, Conditional Frequency Distribution, Lexical Resources, Accessing text from web, Text Processing using Strings : Unicode, Regular Expressions Normalizing Text :Tokenizing Text, Stemming, Lemmatization, Segmentation, Formatting	
Module 2	**TAG AND TEXT**		1
	LOs: Learners will be able to • Gain expertise in categorizing and tagging words using taggers and	**Module Contents:** • **Categorizing and Tagging Words:** Using a Taggers, Tagged Corpora Mapping words to properties	

	Python dictionaries. • Learn the application of machine learning algorithms, including Decision Trees and Naïve Bayes Classifier, for text classification. • Understand the process of supervised classification and acquire skills in evaluating the performance of the classifier.	using Python Dictionaries ,Tagging, How to determine category of a word • **Learning to Classify Text:** Using Machine Learning Algorithms to create classifiers, Supervised Classification, Decision Tree, Naïve Bayes Classifier, and Evaluation of the Classifier.	
Module 3	**INFORMATIONAND SENTENCE ANALYSIS**		1
	LOs: Learners will be able to • Develop expertise in extracting information from text, covering Information Extraction, Chunking, Named Entity Recognition, and Relation Extraction. • Understand the intricacies of analyzing sentence structures, including grammatical dilemmas, the use of syntax, context-free grammar, parsing with context-free grammar, and dependency grammar. • Gain practical skills in developing and evaluating chunkers, as well as handling recursion in linguistic structure.	**Module Contents:** • **Extracting Information from the Text: Information Extraction :**Information Extraction, Chunking, Developing and Evaluating Chunkers, Recursion in Linguistic Structure, Named Entity Recognition, Relation Extraction • **Analysing, Sentence Structure:** Grammatical Dilemmas, What's the use of syntax? Context free Grammar, Parsing with Context free Grammar, Dependency and Dependency Grammar	
Module 4	**Building feature based Grammar**		1
	LOs: Learners will be able to • Acquire proficiency in building feature-based grammar, covering grammatical features and processing feature structures. • Explore the semantics of sentences, delving into Natural Language Understanding, Propositional Logic, First Order Logic (Predicate Logic), and Discourse Semantics. • Develop an understanding	**Module Contents:** • **Building feature based Grammar:** Grammatical Features, Processing Feature Structures Organizational Learning and Transformation, Extending a Feature-Based Grammar • **Analysing the Meaning of Sentences:** Natural Language Understanding, Propositional Logic, First Order Logic (Predicate Logic)The Semantics of English Sentences, Discourse Semantics	

	of organizational learning and transformation, along with extending feature-based grammar to enhance linguistic analysis capabilities.		
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking: • Apply advanced Natural Language Processing (NLP) techniques to analyze and extract information from a given dataset. • Build a feature-based grammar for a specific language or domain of interest. • Analyze the meaning of sentences using propositional logic. • Investigate and apply discourse semantics to a set of interconnected sentences. • Develop an NLU system for a specific application (e.g., sentiment analysis, information extraction).		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
415623	**Deep Learning Lab: Practical Major (Core)**		**2**
	Course Outcomes: **Learners will be able to:** • Master fundamental deep learning concepts like CNNs, RNNs, LSTMs, autoencoders, and GANs using TensorFlow. • Apply deep learning techniques to image and text processing tasks, showcasing practical skills in number prediction, text classification, and sentiment analysis. • Demonstrate proficiency in unsupervised learning and dimensionality reduction through autoencoders, and grasp the applications of GANs in generating synthetic data.		
Module 1	**Implement using TensorFlow**		1
	LOs: Learners will be able to • Gain practical expertise in performing Eigen Values and Eigen Vectors calculations using TensorFlow. • Demonstrate hands-on skills in implementing Neural Networks for XOR operations and binary classification tasks. • Apply Neural Networks to real-world scenarios by performing Breast Cancer Classification, showcasing practical applications in medical data analysis.	**Module Contents:** • Practical to perform Eigen Values and Eigen Vectors using TensorFlow. • Practical to perform XOR Using Neural Networks. • Practical to perform Binary Classification Using Neural Networks. • Practical to perform Breast Cancer Classification Using Neural Networks	
Module 2	**Algorithm Implementation**		1
	LOs: Learners will be able to • Master the implementation of Number Prediction using Convolutional Neural Networks (CNN), showcasing image classification skills. • Demonstrate expertise in Text Classification using Recurrent Neural Networks (RNN), emphasizing sequential data processing. • Implement Movie Review Text Classification using Bi-Directional Long Short-Term	**Module Contents:** • Implement Number prediction using CNN • Implement Text Classification using RNN • Implement Movie Review Text Classification using Bi-Directional LSTM • Practical to implement Autoencoders. • Implement GANS algorithm using TensorFlow	

	Memory (LSTM) networks, showcasing advanced natural language processing.		
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	These assignments aim to apply theoretical concepts to practical application and critical thinking: • Implement a CNN for number prediction on a dataset like MNIST. • Develop an RNN for text classification on a dataset such as sentiment analysis. • Implement a Bi-Directional LSTM for movie review sentiment analysis. • Implement autoencoders for dimensionality reduction or data reconstruction on a chosen dataset. • Implement a GAN for generating synthetic data in a chosen domain (e.g., images, text).		

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Goodfellow, Ian, Bengio, Yoshua, Courville, Aaron. *Deep Learning* (Adaptive Computation and Machine Learning series). The MIT Press, 2016.

Chollet, François. *Deep Learning with Python*. Manning, 2018.

Buduma, Nikhil, Locascio, Nicholas. *Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms*. O'Reilly Media, 2017.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
415624	**Natural Language Processing Lab: Practical** **Major (Core)**		**2**
	Course Outcomes: **Learners will be able to:** • Demonstrate practical skills in linguistic analysis by performing tokenization, stop word identification, stemming, and lemmatization for English and Hindi text. • Apply advanced text processing techniques, including Named Entity Recognition (NER), Chunking, WordNet usage, and Word Similarity checks in English text. • Develop the ability to create word clouds, visually representing word frequencies, and implement text summarization for condensing information. • Gain proficiency in implementing Word2Vec on Wikipedia articles, enhancing semantic understanding and exploring word similarities. • Apply NLP techniques to train a model for Movie Review Classification, showcasing the practical use of linguistic analysis in sentiment analysis and document classification.		
Module 1	**POS Tagging and Name Entity Recognition**		1
	LOs: Learners will be able to • Develop practical programming skills to perform tokenization for both English and Hindi text at the word and sentence levels. • Implement a program to identify stop words in English and Hindi sentences, enhancing text preprocessing capabilities. • Write programs for stemming and lemmatization, demonstrating proficiency in reducing words to their base forms for English text. • Develop a program for part-of-speech (POS) tagging, enabling the identification and categorization of words in English text. • Implement a program for Named Entity Recognition (NER) and Chunking, showcasing the ability to extract and categorize entities	**Module Contents:** • Practical program to perform tokenization over word and sentence on English and Hindi Text. • Write a Program to identify Stop Words in a given sentence in English and Hindi. • Write a program to perform Stemming and Lemmatization for English Text • Write a program to segregate Part of Speech (POS TAGGING) for English Text • Write a program to perform Named Entity Recognition (NER) & Chunkingon English Text.	

	in English text.		
Module 2	**Syntactic and Semantic Analysis**		1
	LOs: Learners will be able to • Develop programming skills to implement WordNet and assess word similarity in English text. • Write a program to create a word cloud, providing a visual representation of word frequencies in English text. • Implement text summarization using programming, showcasing the ability to condense information effectively. • Develop a program to apply Word2Vec on Wikipedia articles, calculating word similarities for better contextual understanding. • Train a model for Movie Review Classification using Natural Language Processing (NLP) techniques, demonstrating proficiency in sentiment analysis and document classification.	**Module Contents:** • Write a program to perform WordNet& also check Word Similarity onEnglish text. • Write a program to implement word cloud of English text. • Write a program to process Text Summarization. • Write a program to implement Word2Vec on Wikipedia Articles and finding the similarity between the words. • Train a model for Movie Review Classification using NLP Techniques	
Assignments/ Activities towards Comprehensive Continuous Evaluation			
	These assignments aim to apply theoretical concepts to practical application and critical thinking: • Choose a dataset containing tweets (positive, negative, neutral sentiments). • Develop an NLP pipeline for sentiment analysis. • Perform tokenization, stemming/lemmatization, and remove stop words. • Address issues like emoji and URL handling. • Utilize techniques like TF-IDF or word embeddings for feature representation. • Train a classification model (e.g., Logistic Regression, Naive Bayes, or a deep learning approach). • Evaluate the model's performance using appropriate metrics (accuracy, precision, recall, F1 score). • Create visualizations (e.g., word clouds, confusion matrix) to enhance interpretation. • Python code for the NLP pipeline. • Model evaluation metrics and visualizations. • A report summarizing the approach, challenges faced, and insights gained.		

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Indurkhya, N., & Damerau, F. J. (2010). *Handbook of Natural Language Processing.* CRC Press Taylor and Francis Group. (2nd ed.)

Manning, Christopher, and Heinrich Schutze. (2009). *Natural Language Processing With Python.* Wiley Publications.

SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
325611	**Information Security** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand the services and mechanisms provided by symmetric ciphers. • Analyse the OSI Security Architecture and its relevance to information security. • Describe classical encryption techniques within the symmetric cipher model. • Explain the principles of public key cryptography. • Understand digital signatures. • Explore authentication applications, including Kerberos and X.500 Authentication Service. • Analyse malicious software, including viruses and related threats, and countermeasures		
Module 1	**Symmetric Ciphers**		1
	LOs: Learners will be able to • Explain the fundamental services provided by symmetric ciphers. • Identify and defend against common attacks on symmetric ciphers. • Analyze the OSI Security Architecture and its role in network security. • Describe classical encryption techniques, including substitution and transposition. • Understand the principles of block ciphers, focusing on the Data Encryption Standard (DES). • Evaluate the strength and weaknesses of DES through differential and linear cryptanalysis. • Apply block cipher design principles to create secure encryption algorithms. • Explain different modes of operation used by block ciphers for secure communication.	**Module Contents:** • **Overview** – Services, Mechanism and Attacks, The OSI Security. Architecture, A model for network security Classical Encryption techniques – Symmetric Cipher model, Substitution. Techniques, Transposition techniques, Rotor Machines, Steganography. Block Cipher and Data Encryption Standard – Simplified DES, Block. Chiper principles, The Data Encryption Standard, The strength of DES, Differential and Linear Cryptanalysis, Block Cipher design principles, Block Cipher mode of Operation	
Module 2	**Asymmetric Ciphers**		1
	LOs: Learners will be able to • Understand the principles of public key cryptography and its applications. • Explain the RSA algorithm, including key management	**Module Contents:** • Public Key Cryptography and RSA – Principles of Public Key Cryptosystems, The RSA Algorithm Key management ; Other public key cryptosystemsKey	

	practices. • Compare different public key cryptosystems and assess their strengths and weaknesses. • Describe the principles and applications of Diffie-Hellman key exchange and elliptical curve cryptography. • Discuss authentication requirements and functions in secure communication. • Explain the principles of message authentication codes and secure hash functions. • Understand the role of digital signatures and authentication protocols in information security.	Management, Diffe-Hellman Key Exchange, Elliptical Curve Arithmetic, Elliptical curve Cryptography Message Authentication and HASH Functions – Authentication requirements, Authentication Functions, Message Authentication Codes, Hash Functions, security of Hash Functions and MACS Digital Signatures and Authentication Protocols – Digital Signatures, Authentication Protocols, Digital Signature Standard	
Module 3	**Network Security practice**		1
	LOs: Learners will be able to • Implement and configure authentication protocols such as Kerberos and X.500. • Utilize Pretty Good Privacy (PGP) and S/MIME for secure email communication. • Understand the architecture and components of IP Security (IPSec). • Implement IPSec components, including Authentication Header (AH) and Encapsulating Security Payload (ESP). • Demonstrate proficiency in combining Security Associations and key management in IPSec. • Identify and mitigate web security threats and vulnerabilities. • Implement SSL/TLS protocols for securing web communication. • Understand the principles and applications of Secure Electronic Transaction (SET) in e-commerce.	**Module Contents:** • **Network Security practice** : Authentication Applications – Kerberos, X.500 Authentication Service Electronic Mail Security – Pretty Good Privacy, S/MIME IP Security – IP Security Overview, IP Security Architecture, Authentication Header, Encapsulating security payload, Combining Security Associations, Key Management WEB Security – Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction	
Module 4	**System Security**		1
	LOs: Learners will be able to • Implement and configure intrusion detection systems for proactive threat identification. • Design and enforce effective password management policies and practices. • Implement countermeasures against viruses and related threats.	**Module Contents:** • System Security : Intruders – Intruders, Intruder detection, Password Management, Malicious Software – Viruses and Related Threats, Virus Countermeasures, Firewall design principles, Trusted system.	

	• Design and configure firewalls based on security requirements. • Understand and implement different types of firewalls for network security. • Recognize the concept of trusted systems and implement mechanisms to build and maintain trust in computing environments		
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • In groups, analyse the case studies to identify the type of malware involved, the attack vectors, and the impact on the affected systems. • Set up a simulated network environment with a variety of devices and services. • Research and identify characteristics that contribute to the trustworthiness of a computing system. • Apply the checklist to evaluate a given computing environment and provide recommendations for enhancing trust. • In pairs or small groups, task students with configuring a firewall to secure the network		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
325612	**Cloud Computing** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • After completion of course, students would be able to: • Identify security aspects of each cloud model • Develop a risk-management strategy for moving to the Cloud • Implement a public cloud instance using a public cloud service provider • Apply trust-based security model to different layer		
Module 1	**Introduction to Cloud Computing:**		1
	LOs: Learners will be able to • Define and explain the concept of cloud computing. Identify the key characteristics, service models (IaaS, PaaS, SaaS), and deployment models (public, private, hybrid) of cloud computing. • Provide an overview of the historical development of cloud computing. Explain the evolution from traditional computing models to cloud computing. • Compare and contrast major cloud service providers such as Amazon Web Services (AWS), Microsoft Azure, and Google Cloud Platform (GCP). • Identify and analyze potential security risks and challenges associated with cloud computing.	**Module Contents:** • Introduction to Cloud Computing • Online Social Networks and Applications • Cloud introduction and overview • Different clouds, Risks, Novel applications of cloud computing	
Module 2	**Cloud Computing Architecture, Cloud Deployment Models**		1
	LOs: Learners will be able to: • Define the requirements that led to the emergence of cloud computing. • Provide an overview of the basic principles and concepts underlying cloud computing. • Explain CPU virtualization and its role in cloud architectures. • Discuss different hypervisors and their features. • Define and explain the SPI (Software as a Service, Platform as a Service, Infrastructure as a Service) framework. • Identify the key drivers motivating organizations to adopt cloud computing. • Evaluate the impact of cloud	**Module Contents:** • **Cloud Computing Architecture:** Requirements, Introduction Cloud computing architecture, On Demand Computing Virtualization at the infrastructure level, Security in Cloud computing environments, CPU Virtualization, A discussion on Hypervisors Storage Virtualization Cloud Computing Defined, The SPI Framework for Cloud Computing, The Traditional Software Model, The Cloud Services Delivery Model • **Cloud Deployment Models:**	

	computing on end-users and businesses. • Explore best practices for establishing effective governance structures in cloud environments	Key Drivers to Adopting the Cloud, The Impact of Cloud Computing on Users, Governance in the Cloud, Barriers to Cloud Computing Adoption in the Enterprise	
Module 3	**Security Issues in Cloud Computing and Access management**		1
	LOs: Learners will be able to • Understand the importance of infrastructure security in cloud computing and identify key components involved. • Explain network-level security measures and protocols relevant to cloud environments. • describe application-level security practices and challenges specific to cloud-based applications. • Understand the significance of data security and storage in cloud computing environments. • Assess the security considerations related to data managed by cloud service providers. • Define trust boundaries and explain their significance in Identity and Access Management • Familiarize with key standards and protocols used for Identity and Access Management in cloud services. • Understand the concept of authorization management in the cloud and its role in ensuring secure access.	**Module Contents:** • **Security Issues in Cloud Computing**: Infrastructure Security, Infrastructure Security: The Network Level, The Host Level, The Application Level, Data Security and Storage, Aspects of Data Security, Data Security Mitigation Provider Data and Its Security. • **Identity and Access Management:** Trust Boundaries and IAM, IAM Challenges, Relevant IAM Standards and Protocols for Cloud Services, IAM Practices in the Cloud, Cloud Authorization Management.	
Module 4	**Security Management in the Cloud, Privacy Issues**		1
	LOs: Learners will be able to • Understand and apply security management standards relevant to cloud computing. • Differentiate availability management practices for Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). • Conduct risk assessments specific to cloud security and propose effective mitigation strategies. • Develop and implement incident response plans tailored to cloud computing scenarios.	**Module Contents:** • **Security Management in the Cloud:** Security Management Standards, Security Management in the Cloud, Availability Management: SaaS, PaaS, IaaS. • **Privacy Issues:** Privacy Issues, Data Life Cycle, Key Privacy Concerns in the Cloud, Protecting Privacy, Changes to Privacy Risk Management and Compliance in Relation to	

	• Analyse the data life cycle and identify key points for addressing privacy concerns in each phase. • Identify and prioritize key privacy concerns that arise in cloud computing environments. • Propose and evaluate measures for protecting privacy in the cloud, including encryption and access controls. • Understand the legal and regulatory landscape related to privacy in cloud computing. • Summarize and interpret relevant U.S. laws and regulations pertaining to privacy in cloud computing.	Cloud Computing, Legal and Regulatory Implications, U.S. Laws and Regulations, International Laws and Regulations.	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Research and compare three major cloud service providers (e.g., AWS, Azure, Google Cloud) based on their service offerings, pricing models, and customer reviews. • Design a hypothetical cloud infrastructure for a given business scenario. Consider factors such as scalability, security, and cost-effectiveness. • Conduct a security risk assessment for a given cloud-based application. Identify potential vulnerabilities and propose mitigation strategies. • Develop a comprehensive security policy for a fictional organization migrating to the cloud. Address key security management standards and practices.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
325613	**Robotic Process Automation** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Define and explain the fundamental concepts and principles of Robotic Process Automation. • Gain proficiency in using popular RPA tools such as UiPath, Automation Anywhere, or Blue Prism. • Develop RPA bots to automate specific tasks and processes. • Diagnose and troubleshoot common issues encountered during RPA implementation.		
Module 1	**Robotic Process Automation Foundations, UiPath, Automation Anywhere**		1
	LOs: Learners will be able to • Understanding RPA Fundamentals, RPA Capabilities and Components, Benefits and Downsides of RPA, Comparison with Other Business Technologies. • Comparison with Other Business Technologies, Automation Anywhere Overview.	**Module Contents:** • What is RPA, Flavors of RPA, History of RPA, What can RPA do, Components of RPA, The Benefits of RPA, The Downsides of RPA, RPA Compared to BPO, BPM, BPA, What is the Difference Between AI and RPA, RPA Tools and Platforms, Consumer Willingness for Automation, The Workforce of the Future • What is UiPath, UiPath Studio, UiPath Robot, UiPath Orchestrator, UiPath – an integrated view • What is Automation Anywhere, Enterprise Control Room, IQ Bot.	
Module 2	**Downloading and Installing UiPath Studio and Data Manipulation**		1
	LOs: Learners will be able to • UiPath Studio and Task Recorder Proficiency, Workflow Sequencing and Control Flow. • Variables, Scope, and Collections, Arguments, Clipboard Management. • Data Table Usage, File Operations, CSV/Excel Handling.	**Module Contents:** • Learning UiPath Studio, Task Recorder, Step by step examples using the recorder • Sequencing the workflow, Activities, Control flow, various types of loops, and decision making, Step by step example using Sequence, Flowchart and Control Flow, Log Message. • Variables and scope, Collections, Arguments – purpose and use, Data table usage with examples, Clipboard management, File operation with step-by-step	

		example, CSV/Excel to data table and vice versa.	
Module 3	**Taking Control of the Controls, Exception Handling and Debugging**		1
	LOs: Learners will be able to • UI Automation Basics, Advanced Automation Plugins • Assistant Bots and Triggers. • Error Handling and Debugging	**Module Contents:** • Finding and attaching windows, Finding the control, Techniques for waiting for a control, Act on controls – mouse and keyboard activities, Working with UiExplorer, Handling events, Revisit recorder, Screen Scraping, When to use OCR, Types of OCR available, Avoiding typical failure points • Terminal plugin, SAP automation, Java plugin, Citrix automation, Mail plugin, PDF plugin, Web integration, Excel and Word plugins, Credential management, Extensions – Java, Chrome, Firefox and Silverlight • What are assistant bots, Monitoring system event triggers, Monitoring image and element triggers, Launching an assistant bot on a keyboard event. • Exception handling, Common exceptions and ways to handle them, Logging and taking screenshots, Debugging techniques, Collecting crash dumps, Error reporting	
Module 4	**Managing and Maintaining the Code.**		1
	LOs: Learners will be able to • Updates, Project Organization, • Reusability of Workflows, State Machine. • Using Config Files and Examples of a Config File, Using Orchestration Server to Control Bots, Publishing and Managing.	**Module Contents:** • Updates Project organization, Nesting workflows, Reusability of workflows, Commenting techniques, State Machine, When to use Flowcharts, State Machines or Sequences, Using config files and examples of a config file, Integrating a TFS Server • Publishing using publish utility, Overview of Orchestration Server, Using Orchestration Server to Control bots, Using	

		Orchestration server to deploy bots, License management, Publishing and managing	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Discuss the importance of metadata in data warehousing, to create a metadata management plan for a given data warehouse, outlining how metadata will be collected, stored, and utilized. • From a dataset extract relevant information, transform it according to a predefined business rule, and load it into a data warehouse. • Create a set of business queries related to a hypothetical business problem • Find a dataset suitable for clustering analysis. then use clustering algorithms to identify natural groupings within the data and interpret the results. • web mining project (perform web scraping, and apply web mining techniques)	

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
325614	**Social Network Analysis** **Major(Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Understand the basics of networks and relations, differentiating between binary and valued relationships, symmetric and asymmetric relationships, and multimode relationships. • Apply graph theory for social network analysis, including techniques such as adjacency matrices, edge-lists, graph traversals, and distances. Gain insights into ego-centric and socio-centric density, clustering, and the development of social network analysis. • Explore the role of ontology in the Semantic Web and its application in network data representation. • Analyze networks, centrality, and centralization in Social Network Analysis (SNA), covering density, reachability, connectivity, reciprocity, ego networks, structural holes, and centrality measures. • Learn techniques for detecting communities in web social networks, evaluating communities, and applying community mining algorithms. • Understand measures of similarity and structural equivalence in SNA, exploring approaches to network positions, social roles, and clustering methods. • Gain proficiency in understanding two-mode networks, including bipartite data structures and quantitative analysis using two-mode Singular Value Decomposition (SVD) analysis. • Apply qualitative analysis techniques, such as two-mode core-periphery analysis and affiliation and attribute networks, to understand and analyze complex relationships within networks.		
Module 1	**Introduction to social network analysis (SNA)**		1
	LOs: Learners will be able to • Proficient in analyzing relationships within networks, distinguishing between binary and valued, symmetric and asymmetric relationships, and understanding multimode relationships. They will also acquire skills in utilizing graph theory techniques, including adjacency matrices, edge-lists, and graph traversals for social network analysis, discerning between ego-centric and socio-centric density • Applying clustering methods in the context of social networks, linking theory development with practical electronic sources such as blogs and online communities.	**Module Contents:** • **Introduction to networks and relations**- analyzing relationships to understand people and groups, binary and valued relationships, symmetric and asymmetric relationships, multimode relationships, • **Using graph theory for social networks analysis-** adjacency matrices, edge-lists, adjacency lists, graph traversals and distances, social networks vs. link analysis, ego-centric and socio-centric density , clustering. • **Social Network analysis:** Development of Social	

		Network Analysis, Electronic sources for network analysis, Blogs and online communities.	
Module 2	**Networks, Centrality, centralization and Ontology**		1
	LOs: Learners will be able to • Profound understanding of ontology and its role in the Semantic Web, encompassing ontology-based knowledge representation, Resource Description Framework, and ontological representation of social individuals and relationships. Additionally, they will acquire expertise in Social Network Analysis (SNA), • Comprehending network characteristics such as density, reachability, and reciprocity, as well as centrality measures, including degree, closeness, betweenness centrality, and the Google PageRank algorithm, with an emphasis on interpreting and visualizing network structures.	**Module Contents:** • **Ontology and their role in the Semantic Web:** Semantic Web , Ontology, Ontology based knowledge Representation , Resource Description Framework – Web Ontology ,State-of-the-art in network data representation ,Ontological representation of social individuals ,Ontological representation of social relationships. • **Networks, Centrality and centralization in SNA Understanding networks**-density, reachability, connectivity, reciprocity, group-external and group-internal ties in networks, ego networks, extracting and visualizing ego networks, structural holes, Centrality-degree of centrality, closeness and betweenness centrality, local and global centrality, centralization and graph centers, notion of importance within network, Google pagerank algorithm.	
Module 3	**Extraction and mining communities in web social networks**		1
	LOs: Learners will be able to • Proficient in detecting, defining, and evaluating communities in web social networks • Utilizing various community detection methods, and applying community mining algorithms with tools like Girvan Newman. • Additionally, they will grasp measures of similarity and structural equivalence in Social Network Analysis (SNA), exploring approaches to defining and finding equivalence sets, using brute force and Tabu search, • Understanding clustering techniques, including agglomerative and divisive clusters, and diverse similarity metrics such as Euclidean, Manhattan, Jaccard, and Hamming distances.	**Module Contents:** • **Communities in Web Social Network:** Detecting communities in social networks, Definition of community, Evaluating communities, Methods for community detection and mining,Applications of community mining algorithms, Tools for detecting communities social network infrastructures and communities , Girvan Newman algorithm ,Decentralized online social networks , Multi-Relational characterization of dynamic social network communities. • **Measures of similarity and**	

		structural equivalence in SNA: Approaches to network positions and social roles-defining equivalence or similarity, structural equivalence, automorphic equivalence, finding equivalence sets, brute force and Tabu search, regular equivalence, equivalence of distances: Maxsim, regular equivalence • **Understanding clustering:** agglomerative and divisive clusters, Euclidean, Manhattan, and squared distances, binary relations, matches , exact, Jaccard, Hamming	
Module 4	**Two-mode networks for SNA**:		1
	LOs: Learners will be able to • Comprehensive understanding of mode networks, encompassing proficiency in utilizing bipartite data structures, visualizing two-mode data, and conducting quantitative analyses through techniques like Singular Value Decomposition (SVD), factor analysis, and correspondence analysis. • They will also be adept at qualitative analysis, employing methods such as core-periphery analysis, factions analysis, and exploring the intricacies of affiliation and attribute networks within two-mode structures.	**Module Contents:** • **Understanding mode networks-** Bipartite data structures, visualizing two-mode data, quantitative analysis using two-mode Singular value decomposition (SVD) analysis, two-mode factor analysis, two-mode correspondence analysis, qualitative analysis using two mode core-periphery analysis, two-mode factions analysis, affiliation and attribute networks	
Assignments/ Activities			
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Write a program to compute the following for a given a network: (i) number of edges, (ii) number of nodes; (iii) degree of node; (iv) node with lowest degree; (v) the adjacency list; (vi) matrix of the graph. • Perform following tasks: (i) View data collection forms and/or import onemode/two-mode datasets; (ii) Basic Networks matrices transformations • Compute the following node level measures: (i) Density; (ii) Degree; (iii) Reciprocity; (iv) Transitivity; (v) Centralization; (vi) Clustering. • For a given network find the following: (i) Length of the shortest path from a given node to another node; (ii) the density of the graph; (iii) Draw egocentric network of node G with chosen configuration parameters. • Write a program to distinguish between a network as a matrix, a network as an edge list, and a network as a sociogram (or "network graph") using 3 distinct networks representatives of each.		

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SN	Courses, Modules and Outcomes	Course Contents	Cr
	Semester IV		
325615	**Agile Methodology** **Major (Elective) Theory**		**4**
	Course Outcomes: **Learners will be able to:** • Apply the Agile requirement techniques for Software Development. • Analyze different Agile software methodologies to facilitate the Project. • Analyze different Agile Estimation Techniques. • Illustrate Agile Testing approach.		
Module 1	**Introduction to Agile Methodologies**		1
	LOs: Learners will be able to • Explain the traditional approach to software development methodology. • Identify the limitations and challenges of traditional software development. • Define the concept of Agile in the context of software development. • Introduce the Class Responsibility Collaborator (CRC) method for collaborative requirements analysis.	**Module Contents:** • Traditional approach of Software Development Methodology, Need of Agile software Development, Defining Agile, Agile Manifesto Principles of Agile , Values of Agile ,Business Benefits of Agile Software Development • Traditional Requirements Development , Principle of Agile Requirements Development ,Agile Requirements : Epics and User stories ,Difference between Epics and User stories ,Backlog Management, Class Responsibility Collaborator.	
Module 2	**Scrum and Kanban Methodologies**		1
	LOs: Learners will be able to • Define the Scrum framework and its role in Agile software development. • Identify and analyze the advantages and benefits of adopting the Scrum framework. • Understand the underlying principles that guide the Scrum framework. • Define and differentiate between key artifacts in Scrum, including the Product Backlog, Sprint Backlog, and Increments. • Define the Kanban framework and its principles. • Understand the concept of workflow in Kanban. • Explain the importance of limiting work in progress in Kanban. • Understand the concept of work item	**Module Contents:** • Introduction to Scrum framework, Advantages of Scrum Framework.Phases of Scrum, Principles of Scrum,Roles: Product owner, team members and scrum master, Scrum Ceremonies :Sprint, sprint planning, daily scrum, sprint review, and sprint retrospective, Artifacts: Product backlog, sprint backlog and increments. • Introduction to Kanban framework, Workflow, Limit the amount of work in progress, pulling work from column to column, Kanban board, Adding policies to the board, Cards and their optimization.Kanban	

	age in Kanban.	Practices , Kanban Flow practices.Work Item Age.Kanban vs Scrum.	
Module 3	**Extreme Programming and Agile Estimation Techniques**		1
	LOs: Learners will be able to • Gain a foundational understanding of the basic values and principles that underpin Extreme Programming (XP). • Learn and apply the twelve practices of Extreme Programming (XP), including pair programming, continuous integration, and test-driven development (TDD). • Explore the life cycle of an XP project, from planning to release. • Gain an understanding of the Agile Maturity Model and its levels, ranging from initial to optimized. • Learn and apply Agile estimation techniques, including Planning Poker, Shirt Sizes, Dot Voting, and the Bucket System. • Explore ways to optimize planning processes using Agile estimation techniques.	**Module Contents:** • Basic values and principles, Roles, Twelve practices of XP, Pair programming, XP team, Life cycle and tools for XP.,Good practices need to be practiced in extreme programming,Advantages of Extreme Programming • Agile Maturity Model and Agile Estimation Techniques - Planning Poker-Shirt Sizes. Dot Voting, Bucket System.	
Module 4	**Agile Testing**		1
	LOs: Learners will be able to • Understand the Agile Testing Quadrants model and its classification of testing activities into four quadrants. • Gain a comprehensive understanding of the Agile Testing Life Cycle and its iterative nature within Agile development. • Learn the principles and practices of Behavior Driven Development (BDD) as an Agile testing technique. • Gain an understanding of Agile test metrics and their role in measuring and improving the testing process. • Learn how to effectively use metrics to assess project progress and identify areas for improvement. • Identify common pitfalls associated with Agile test metrics and learn strategies to avoid them.	**Module Contents:** • Agile Testing Life Cycle, Agile Testing Quadrants, Agile Testing Techniques: Behavior Driven Development, Test Driven Development Acceptance Test Driven Development Testing.Role of Agile Tester.User stories approach in Acceptance Test Driven Development Testing.Other Techniques - Exploratory Testing , Session Based testing. • Agile Test Metrics.	

Assignments/ Activities		
	These assignments aim to apply theoretical concepts to practical application and critical thinking. • Prepare a Product Backlog ,Epics and User Stories for a given scenario. • Write a Class Responsibility Collaborator for a given scenario. • Importance of Scrum Ceremonies in Scrum Framework. • Importance of Scrum Team Roles and Responsibilities. • Problems on Work Item Age. • Depict Kanban workflow. • Use various Agile Estimation Techniques. • Case study on AMM • Prepare Agile Test cases using Behavior Driven Development. • Prepare Agile Test cases using Acceptance Test Driven Development.	

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