JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
DEPARTMENT OF COMPUTER SCIENCE ENGINEERING
R25 M.TECH AI & DS COURSE STRUCTURE AND SYLLABUS

VISION AND MISSION OF THE UNIVERSITY

Vision

The University is primarily promoting quality of education in the areas of Science, Technology, Engineering and Mathematics (STEM) as four academic pillars of education, to excel in teaching, learning, research, consultancy and placements through innovative practices with global perspective.

Mission

1. Design an Industry relevant curriculum from time to time with a Global perspective
2. Promoting quality education by embracing ICT delivery mechanism with continuous pedagogy through   e-learning mechanism
3. Spread across for industry collaborations with a focus to pre-training and placements for technology transfer to society
4. Establishing centers of excellence to promote research and innovations in multidisciplinary areas to bring in patent culture and consultancy practices
5. International Collaborations for student outreach
6. Facilitating international students to study in JNTUK to infuse cross culture learning practices.

Vision and Mission of the Institute

Vision and Mission of the Department

Programme Education Objectives (PEOs) of the M. Tech. (Artificial Intelligence and Data Science)

PEO1: Graduates will acquire deep knowledge in Artificial Intelligence**,** Machine Learning, and Data Science, enabling them to solve complex, real-world problems using cutting-edge techniques and technologies.

PEO2: Graduates will contribute to impactful research, advancing AI and Data Science while adhering to ethical principles, ensuring responsible use of data and technology for societal benefit

PEO3: Graduates will possess strong leadership and communication skills, capable of working effectively in multidisciplinary teams, and will engage in continuous learning to stay at the forefront of evolving technologies.

Mapping of Mission statements to PEOs

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Programme Outcomes (POs)

PO1: An ability to independently carry out research /investigation and development work to solve practical problems

PO2: An ability to write and present a substantial technical report/document

PO3: Students should be able to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: Analyze complex real-world problems and develop data-driven solutions by leveraging advanced programming techniques, big data technologies, and modern computational tools.

PO5: Utilize modern computing frameworks, data visualization tools, and software technologies to perform efficient data analysis and design robust systems which resemble human intelligence.

PO6: Uphold ethical standards, safeguard data privacy, and implement secure practices in handling sensitive information, ensuring responsible and transparent use in both academic and industrial AI applications

Mapping of Programme Outcomes to PEOs

POs/ PEOs	PEO1	PEO2	PEO3
PO1	M	H	M
PO2	L	M	H
PO3	H	M	H
PO4	H	M	M
PO5	H	M	M
PO6	M	H	M

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M.Tech

ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

PROGRAMME COURSE STRUCTURE & SYLLABUS

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R25 M.Tech Artificial Intelligence and Data Science
Programme Structure

I Semester

S. No.	Course Title	L	T	P	C
1	Program Core – 1 Mathematics for Data Science	3	1	0	4
2	Program Core – 2 Artificial Intelligence	3	1	0	4
3	Program Core – 3 Programming for Data Science	3	1	0	4
4	Program Elective – I • Recommender Systems • Natural Language Processing • Quantum Computing	3	0	0	3
5	Program Elective – II • Big Data Frameworks • Web Analytics • Intelligent Systems	3	0	0	3
6	Laboratory – 1 Artificial Intelligence Lab	0	1	2	2
7	Laboratory – 2 Data Science Lab	0	1	2	2
8	Seminar-I	0	0	2	1
	TOTAL	**15**	**5**	**6**	**23**

List of Professional Elective Courses in I Semester (Electives – I & II)

S.No.	Course Title
1	Recommender Systems
2	Natural Language Processing
3	Quantum Computing
4	Big Data Frameworks
5	Web Analytics
6	Intelligent Systems

@ Minimum 2/3 themes per elective

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II Semester

Sl. No.	Course Title	L	T	P	C
1	Program Core – 4 Deep Learning	3	1	0	4
2	Program Core – 5 Data Visualization	3	1	0	4
3	Program Core – 6 Feature Engineering for Machine Learning	3	1	0	4
4	Program Elective – III • Fuzzy Logic and Fuzzy Sets • Social Networking and Mining • Data Preparation and Analysis	3	0	0	3
5	Program Elective – IV • Scalable Systems for Data Science • Business Intelligence Tools • Data Engineering	3	0	0	3
6	Laboratory – 3 Deep Learning Lab	0	1	2	2
7	Laboratory – 4 Data Visualization Lab	0	1	2	2
8	Seminar – II	0	0	2	1
	TOTAL	**15**	**5**	**6**	**23**

* During the summer break, students need to pursue Summer Internship/ Industrial Training, which will be evaluated in the III Sem.

List of Professional Elective Courses in II Semester (Electives III & IV)

S.No.	Course Title
1	Fuzzy Logic and Fuzzy Sets
2	Social Networking and Mining
3	Data Preparation and Analysis
4	Scalable Systems for Data Science
5	Business Intelligence Tools
6	Data Engineering

@ Minimum 2/3 themes per elective

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III Semester

S. No.	Course Title	L	T	P	C
1	Research Methodology and IPR / *Swayam 12 week MOOC course – RM&IPR*	3	0	0	3
2	Summer Internship/ Industrial Training (8-10 weeks)*	-	-	-	3
3	Comprehensive Viva#	-	-	-	2
4	Dissertation Part – A$	-	-	20	10
	TOTAL	**3**	**-**	**20**	**18**

* Student attended during summer / year break and assessment will be done in 3rd Sem.

\# Comprehensive viva can be conducted courses completed upto second sem.

\$ Dissertation – Part A, internal assessment

IV Semester

Sl. No.	Course Title	L	T	P	C
1	Dissertation Part – B%	-	-	32	16
	TOTAL	**-**	**-**	**32**	**16**

% External Assessment

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I Semester	MATHEMATICS FOR DATA SCIENCE	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Understand and apply the fundamental concepts of set theory, binary operations, functions, relations, and probability theory in mathematical problem-solving.
2. Develop proficiency in calculus and differential equations, including techniques like logarithmic differentiation, partial differentiation, and maxima/minima optimization.
3. Master matrix algebra, determinants, and linear algebra, including topics such as eigenvalues, eigenvectors, and matrix diagonalization.
4. Explore the concepts of linear transformations, vector spaces, and their applications in advanced computational problems like AI and ML models.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand set theory, binary operations, and relations	K2
CO2	Solve problems involving differentiation and integration	K3
CO3	Apply matrix operations and linear algebra in problem-solving	K3
CO4	Utilize linear transformations and vector spaces for mathematical modeling	K2
CO5	Develop skills in using Boolean algebra and propositional calculus for logical reasoning	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	H	M	L
CO2	M	M	H	H	H	M
CO3	H	M	H	H	H	L
CO4	M	M	H	H	M	L
CO5	M	H	M	H	M	M

- (Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Set Theory: Binary Operations, Functions and Relations, Recurrencerelations and Generating Functions, Permutations and Combinations: Pigeon Hole Principle, Probability Theory, Prepositional calculus, Tautology & Contradiction, Boolean Algebra, Idea of Continuity.	12

UNIT – 2	Differentiation: Logarithmic differentiation, Partial differentiation, Euler's Theorem for Homogenous Functions, Maxima and Minima. Integration: Double Integration, Range of Order of Integration, Find Ideas; Vectors: dot product, cross product, Divergence and convergence of a vector.	12
UNIT – 3	Matrices & Determinants: Matrix, Def., types, Addition, Subtraction, Multiplication of Matrices, Singular and Non-Singular Matrices, Rank of a Matrix, Solution of Simultaneous Equations, Cayle Hamilton Theorem, Eigen Values & Eigen Vectors, Diagonalization of a Matrix, Concept of Positive Definite, Semi Definite.	12
UNIT – 4	Matrix Algebra and Linear Algebra: Introduction of groups, rings and Vector Spaces. Linear Independence and Dependence of Vectors, Linear Combination. Basis and Dimension of Vector space, Sub-Space, Intersection, Union of sub Spaces.	12
UNIT – 5	Linear Transformation: Matrices as Linear Mapping, Kernel and Image. Statement of Rank Nullity Theorem, Singular and Non- Regular Linear Mappings.	12
	Total	60

Text Books:
1. Seymour Lipschutz, Marc Lipson, "*Linear Algebra*", 6th Edition, Schaum Series, 2018.
2. Seymour Lipschutz, Marc Lipson, H. Patil, "*Discrete Mathematics*", 3rd Edition, Schaum Series, 2017.
3. Elliott Mendelson, Frank Ayres, "*Calculus*", 6th Edition, Schaum Series, 2012.
4. Philip N. Klein, "*Coding the Matrix: Linear Algebra Through Applications to Computer Science*", Newtonian Press, 2013.
5. Sheldon Axler, "*Linear Algebra Done Right*", 3rd Edition, Springer, 2015.

Reference Books:
1. Kenneth H. Rosen, Discrete Mathematics and Its Applications, 7th Edition, McGraw-Hill Education, 2011.
2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, Wiley, 2011.
3. Gilbert Strang, Introduction to Linear Algebra, 5th Edition, Wellesley-Cambridge Press, 2016.
4. Dimitri P. Bertsekas and John N. Tsitsiklis, Introduction to Probability, 2nd Edition, Athena Scientific, 2008.
5. J. Eldon Whitesitt, Boolean Algebra and Its Applications, Dover Publications, 1995.

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I Semester	ARTIFICIAL INTELLIGENCE	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Provide students with a foundational understanding of artificial intelligence, its history, intelligent systems, and the various AI applications in real-world scenarios.
2. Introduce problem-solving techniques in AI, including state-space search, control strategies, heuristic searches, and constraint satisfaction.
3. Explore advanced topics in knowledge representation, including semantic networks, frames, and conceptual dependency theory, and their application in AI systems.
4. Study uncertainty and fuzzy logic in AI, including probability theory, Bayesian networks, and fuzzy systems, and understand their applications in decision-making processes.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the fundamentals of AI and its history, and apply intelligent systems to real-world problems	K2
CO2	Analyze and apply search techniques and problem-solving strategies in AI systems	K3
CO3	Apply knowledge representation techniques like semantic networks, frames, and conceptual dependency in AI systems	K3
CO4	Apply uncertainty measures in AI systems using probability theory, Bayesian networks, and fuzzy logic	K3
CO5	Critically evaluate AI systems and algorithms based on problem-solving capabilities, knowledge representation, and handling of uncertainty	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	M	M	L
CO2	M	M	H	H	H	M
CO3	M	M	H	H	M	L
CO4	M	M	M	H	H	M
CO5	H	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction to artificial intelligence: Introduction, history, intelligent systems, foundations of AI, applications, tic-tac-tie game playing, development of AI languages, current trends in AI, Problem solving: state-space search and control strategies: Introduction, general problem solving, characteristics of problem, exhaustive searches, heuristic search techniques, iterative-deepening a*, constraint satisfaction	12
UNIT – 2	Problem reduction and game playing: Introduction, problem reduction, game playing, alpha-beta pruning, two-player perfect information games, Logic concepts: Introduction, propositional calculus, proportional logic, natural deduction system, axiomatic system, semantic tableau system in proportional logic, resolution refutation in proportional logic, predicate logic	12
UNIT – 3	Knowledge representation: Introduction, approaches to knowledge representation, knowledge representation using semantic network, extended semantic networks for KR, knowledge representation using frames, advanced knowledge representation techniques: Introduction, conceptual dependency theory, script structure, cyc theory, case grammars, semantic web.	12
UNIT – 4	Uncertainty measure: probability theory: Introduction, probability theory, Bayesian belief networks, certainty factor theory, dempster-shafer theory	12
UNIT – 5	Fuzzy sets and fuzzy logic: Introduction, fuzzy sets, fuzzy set operations, types of membership functions, multi valued logic, fuzzy logic, linguistic variables and hedges, fuzzy propositions, inference rules for fuzzy propositions, fuzzy systems.	12
	Total	60

Text Books:

1. Artificial intelligence, A modern Approach, 2nded, Stuart Russel, Peter Norvig, Prentice Hall
2. Artificial Intelligence, SarojKaushik, 1st Edition, CENGAGE Learning, 2011.

Reference Books:

1. Artificial intelligence, structures and Strategies for Complex problem solving, 5th Edition, George F Lugar, PEA
2. Introduction to Artificial Intelligence, Ertel, Wolf Gang, Springer, 2017
3. Artificial Intelligence, A new Synthesis, 1st Edition, Nils J Nilsson, Elsevier, 1998
4. Artificial Intelligence- 3rd Edition, Rich, Kevin Knight, Shiv Shankar B Nair, TMH
5. Introduction to Artificial Intelligence and Expert Systems, 1st Edition, Patterson, Pearson India, 2015

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I Semester	PROGRAMMING FOR DATA SCIENCE	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Provide students with a comprehensive understanding of fundamental concepts in data science, including basic terminologies, types of data, and the steps involved in a data science workflow.
2. Introduce students to key data manipulation and analysis tools, including NumPy for arrays and vectorized computation, and Pandas for data exploration, cleaning, and wrangling.
3. Teach students effective data visualization techniques using tools like Matplotlib, Pandas, and Seaborn, and how to summarize and aggregate data.
4. Equip students with knowledge of statistical thinking, distributions, and time series analysis, enabling them to analyze data effectively and make inferences.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand basic concepts in data science, types of data, and the five steps of data science	K2
CO2	Apply NumPy and Pandas for data exploration, cleaning, and manipulation	K3
CO3	Create effective data visualizations and aggregate data using Matplotlib and Seaborn	K3
CO4	Perform statistical analysis on data, including distributions and time series analysis	K3
CO5	Analyze and interpret real-world data problems, using the entire data science pipeline	K4

- #Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	M	M	L
CO2	M	M	H	H	H	M
CO3	M	M	H	H	H	M
CO4	M	M	M	H	H	M
CO5	H	M	H	H	H	M

- (Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT –	**Introduction To Data Science:** Basic terminologies of data science,	12

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1	Types of data, five steps of data science, Arrays and vectorized computation using NumPy - The NumPyndarray: A multidimensional array object, Universal functions: Fast element-wise Array functions, Array-oriented Programming with arrays, File input and output with arrays, Linear algebra, pseudorandom number generation.	
UNIT – 2	**Data Exploration With Pandas:** Process of exploring data, Pandas data structures – Series, Data frame, Index objects; Essential functionality, Summarizing and computing descriptive statistics - Correlation and covariance, Unique values, Value counts and membership; Data loading, Storage, and file formats - Reading and writing data in text format, Binary data formats, Interacting with web APIs, Interacting with databases.	12
UNIT – 3	**Data Cleaning, Preparation And Data Wrangling :** Handling missing data, Data transformation, String manipulation - String object methods, Regular expressions, Vectorized string functions in Pandas; Data wrangling: join, Combine and reshape - Hierarchical indexing, Combining and merging datasets, Reshaping and pivoting.	12
UNIT – 4	**Data Visualization With Matplotlib:** Plotting and visualization- A brief matplotlib API primer, Plotting with Pandas and Seaborn, Other python visualization tools; Data aggregation and Group operations-GroupBy mechanics, Data aggregation, Apply: General split-apply-combine, Pivot tables and Cross- tabulation.	12
UNIT – 5	**Statistical Thinking And Time Series Analysis :** Statistical Thinking: Distributions – Representing and plotting histograms, Outliers, Summarizing distributions, Variance, Reporting results; Probability mass function; Cumulative distribution functions - Representing CDFs, Percentile based statistics, Random numbers, Comparing percentile ranks. Time Series Analysis: Date and Time data types and tools, Time series basics, Date ranges, Frequencies, and shifting, Time zone handling, Periods and period arithmetic.	12
	Total	60

Text Books:
1. Wes McKinney, Python for Data Analysis, O'Reilly, 2nd Edition, 2017.
2. Alen B. Downey, Think Stats: Exploratory Data Analysis, O'Reilly Publications, 2nd Edition, 2015.

Reference Books:
1. SinanOzdemir, Principles of Data Science, Packt Publishers, 2nd Edition, 2018.
2. Rachel Schutt, Cathy O'Neil,Doing Data Science: Straight Talk from the Frontline, O'Reilly, 2014.

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I Semester	RECOMMENDER SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:
The objectives of this course are to
1. Introduce students to the fundamental concepts of recommender systems, including taxonomy, problem domains, and the evaluation techniques used in the field.
2. Equip students with the skills needed to implement and apply collaborative filtering algorithms, including user-based and item-based nearest-neighbor methods.
3. Provide an understanding of content-based recommender systems, including item profiles, feature extraction, user profiles, and the use of similarity-based retrieval techniques.
4. Explore advanced topics such as knowledge-based recommendation, hybrid recommender systems, and their evaluation using real-world datasets.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the basic concepts, taxonomy, and evaluation of recommender systems.	K2
CO2	Implement collaborative filtering algorithms for recommendation.	K3
CO3	Implement content-based filtering and develop item/user profiles.	K3
CO4	Design and apply knowledge-based and hybrid recommender systems.	K3
CO5	Evaluate recommender systems using various error metrics and user-centered metrics	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	M	M	L
CO2	M	M	H	H	H	M
CO3	M	M	H	H	H	M
CO4	M	M	M	H	H	M
CO5	H	M	H	H	H	M

- (Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Basic concepts for recommender systems, detailed taxonomy of recommender systems, Evaluation of recommender systems	12
UNIT – 2	Collaborative filtering algorithms: User-based nearest neighbour recommendation, Itembasednearest-neighbour recommendation, Model based and pre-processing basedapproaches, Attacks on collaborative recommender systems.	12
UNIT – 3	Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, Obtaining item features from tags, Representing item profiles, Methods forlearning user profiles, Similarity based retrieval, Classification algorithms.	12
UNIT – 4	Knowledge based recommendation: Knowledge representation and reasoning, Constraintbased recommenders, Case based recommenders Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Featurecombination, Feature augmentation, Parallelized hybridization design: Weighted, Switching,Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridizationstrategies	12
UNIT – 5	Evaluating Recommender System: General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics.	12
	Total	60

Text Books:
1. CharuAggarwal "Recommender Systems: The Textbook," First Edition, Springer
2. Francesco Ricci, LiorRokach, and BrachaShapira "Recommender SystemsHandbook," First Edition, Springer

Reference Books:
1. RounakBanik "Hands-On Recommendation Systems with Python," First Edition, Packt Publishing
2. Kim Falk "Practical Recommender Systems," First Edition, Manning Publications
3. Deepak Agarwal and Bee-Chung Chen "Statistical Methods for Recommender Systems," First Edition, Cambridge University Press

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I Semester	NATURAL LANGUAGE PROCESSING	L	T	P	C
		3	0	0	3

Course Objectives:
The main objective of this course is to
1. Provide a foundational understanding of Natural Language Processing (NLP), its components, and different levels of language analysis.
2. Study and implement different grammatical structures and parsing techniques such as top-down, bottom-up parsing, and augmented grammars.
3. Explore the semantic interpretation of natural language, including logical forms, word senses, and the role of ambiguity in NLP tasks.
4. Understand and implement various language modeling techniques and apply them in real-world tasks, such as machine translation, multilingual retrieval, and automatic summarization.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Identify and explain the basic concepts and techniques used in NLP, including different levels of language analysis (e.g., syntax, semantics, pragmatics).	K2
CO2	Evaluate the organization and structure of NLP systems, and identify their key components and functionalities.	K3
CO3	Implement parsing algorithms such as top-down and bottom-up parsers and analyze augmented grammars for language processing tasks.	K3
CO4	Analyze and perform semantic interpretation, resolving ambiguities and mapping language into logical forms for deeper understanding.	K4
CO5	Apply language models, including n-gram models, and implement multilingual information retrieval and automatic summarization systems.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	M
CO2	M	M	H	M	H	M
CO3	M	H	H	M	H	M
CO4	M	H	M	H	M	M
CO5	M	H	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction to Natural language** The Study of Language, Applications of NLP, Evaluating Language Understanding Systems, Different Levels of Language Analysis, Representations and Understanding, Organization of Natural language Understanding Systems, Linguistic Background: An outline of English Syntax.	12
UNIT – 2	**Grammars and Parsing** Grammars and Parsing- Top- Down and Bottom-Up Parsers, Transition Network Grammars, Feature Systems and Augmented Grammars, Morphological Analysis and the Lexicon, Parsing with Features, Augmented Transition Networks.	12
UNIT – 3	**Grammars for Natural Language** Grammars for Natural Language, Movement Phenomenon in Language, Handling questions in Context Free Grammars, Hold Mechanisms in ATNs, Gap Threading, Human Preferences in Parsing, Shift Reduce Parsers, Deterministic Parsers.	12
UNIT – 4	**Semantic Interpretation** Semantic & Logical form, Word senses & ambiguity, The basic logical form language, Encoding ambiguity in the logical Form, Verbs & States in logical form, Thematic roles, Speech acts & embedded sentences, Defining semantics structure model theory. **Language Modeling** Introduction, n-Gram Models, Language model Evaluation, Parameter Estimation, Language Model Adaption, Types of Language Models, Language-Specific Modeling Problems, Multilingual and Cross lingual Language Modeling.	12
UNIT – 5	**Machine Translation** Survey: Introduction, Problems of Machine Translation, Is Machine Translation Possible, Brief History, Possible Approaches, Current Status. Anusaraka or Language Accessor: Background, Cutting the Gordian Knot, The Problem, Structure of Anusaraka System, User Interface, Linguistic Area, Giving up Agreement in Anusarsaka Output, Language Bridges. **Multilingual Information Retrieval** Introduction, Document Preprocessing, Monolingual Information Retrieval, CLIR, MLIR, Evaluation in Information Retrieval, Tools, Software and Resources. **Multilingual Automatic Summarization** Introduction, Approaches to Summarization, Evaluation, How to Build a Summarizer, Competitions and Datasets.	12
	Total	60

Text Books:
1. James Allen, Natural Language Understanding, 2nd Edition, 2003, Pearson Education.
2. Multilingual Natural Language Processing Applications : From Theory To Practice-Daniel M.Bikel and ImedZitouni , Pearson Publications.
3. Natural Language Processing, A paninian perspective, Akshar Bharathi, Vineetchaitanya, Prentice –Hall of India.

Refernces Books:
1. Charniack, Eugene, Statistical Language Learning, MIT Press, 1993.
2. Jurafsky, Dan and Martin, James, Speech and Language Processing, 2nd Edition, PrenticeHall, 2008.
3. Manning, Christopher and Henrich, Schutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.

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I Semester	QUANTUM COMPUTING	L	T	P	C
		3	0	0	3

Course Objectives:
The objectives of this course are to
1. Provide students with a solid foundation in the basic principles of quantum mechanics and quantum computing, including qubits, entanglement, and quantum interference.
2. Teach students how to design and implement quantum circuits and operators, with a particular focus on Grover's algorithm and its practical applications.
3. Explore the methods of storing and encoding data in quantum computers, such as amplitude encoding and dynamic encoding.
4. Introduce students to advanced quantum algorithms, including Quantum Fourier Transform, Quantum Phase Estimation, and Quantum Support Vector Machines, along with near-term algorithms for current quantum devices.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the fundamental concepts of quantum mechanics and quantum computing.	K2
CO2	Implement quantum circuits and algorithms.	K3
CO3	Apply data encoding techniques on a quantum computer	K3
CO4	Develop and implement advanced quantum algorithms.	K3
CO5	Analyze and evaluate quantum algorithms on current quantum devices	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	L	M	M	M	L
CO2	M	M	H	H	H	M
CO3	M	M	H	H	H	M
CO4	M	M	H	H	H	M
CO5	H	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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R25 M.TECH AI & DS COURSE STRUCTURE AND SYLLABUS

UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction to quantum mechanics: Why Quantum Computing, History of Quantum Physics, Qubits, Probabilistic interpretation, Bloch sphere, Interference, Two Qubit states, Entanglement, Qubits versus Bits.	12
UNIT – 2	Introduction to Quantum Computing: Forms of quantum computing, Quantum Computing: Abstraction Levels, Quantum Circuit, Quantum Operators, Single-qubit operators, Ulti-qubit operators, The Power of Quantum, Grover's algorithm.	12
UNIT – 3	Storing Data on a Quantum Computer: Data Representations, Basis encoding, Amplitude encoding, Dynamic encoding.	12
UNIT – 4	Coherent Quantum Computing: Quantum Fourier Transformation, Quantum Phase Estimation, Expectation Values, Matrix Multiplication (HLL), Quantum Random Access Memory, Quantum Support Vector Machines, Adiabatic quantum computing	12
UNIT – 5	Algorithms for Current and Near-Term Quantum Computing Devices: Decoherence, Quantum supremacy, NISQ, Quantum Approximate Optimization Algorithm (QAOA), Variational Quantum Linear Solver, Quantum Annealing, Cloud Quantum Computing	12
	Total	60

Text Books:

1. Eric R. Johnston, NicHarrigan, Mercedes and Gimeno-Segovia "Programming Quantum Computers: Essential Algorithms and Code Samples, SHROFF/ O'Reilly.
2. Dr. Christine Corbett Moran, Mastering Quantum Computing with IBM QX: Explore the world of quantum computing using the Quantum Composer and Qiskit, Kindle Edition Packt.
3. V.K Sahni, Quantum Computing (with CD), TATA McGrawHill.
4. Phillip Kaye, Raymond Laflammeet. al., An introduction to Quantum Computing, Oxford University press, 2007. (1) Chris Bernhardt, Quantum Computing for Everyone, The MIT Press, Cambridge, 2020.
5. David McMahon-Quantum Computing Explained-Wiley-Inderscience, IEEE Computer Society (2008).

Reference Books:

1. Chris Bernhardt, Quantum Computing for Everyone (The MIT Press).
2. Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information", Cambridge (2002).
3. Riley Tipton Perry, "Quantum Computing from the Ground Up", World Scientific Publishing Ltd (2012).

4. Scott Aaronson, "Quantum Computing since Democritus", Cambridge (2013).

5. P. Kok, B. Lovett, "Introduction to Optical Quantum Information Processing", Cambridge.

6. Quantum Computation and Quantum Information, M. A. Nielsen & I. Chuang, Cambridge University Press (2013).

7. Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel and Wolfgang H. Polak MIT press (2014)

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I Semester	**BIG DATA FRAMEWORKS**	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Provide students with a comprehensive understanding of the Hadoop ecosystem, focusing on HDFS architecture, data flow, and parallel processing with Hadoop.
2. Teach students the essentials of developing and deploying MapReduce applications, including cluster management, job tuning, and debugging.
3. Introduce students to Spark components and its architecture, enabling them to manage clusters and resources effectively for Big Data analytics.
4. Explore performance tuning techniques, job execution, and fault tolerance mechanisms in Spark, ensuring efficient data processing and high availability.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the Hadoop ecosystem, HDFS architecture, and data flow	K2
CO2	Develop and optimize MapReduce applications	K3
CO3	Understand Spark architecture and resource management with YARN and Mesos.	K2
CO4	Implement performance tuning and fault tolerance mechanisms in Spark jobs	K3
CO5	Analyze and evaluate job execution in Spark, including scheduling and fault tolerance.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	M	L
CO2	M	M	H	H	H	M
CO3	M	M	M	M	H	M
CO4	M	M	H	H	H	M
CO5	M	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**INTRODUCTION TO HADOOP** Data, Data Storage and Analysis, Querying all your data, Beyond Batch, Comparison with Other Systems, The Design of HDFS, HDFS Concepts, The Command-Line Interface, Hadoop File Systems, The Java Interface, Data Flow, Parallel Copying with distcp.	12
UNIT – 2	**HADOOP OPERATIONS AND DEVELOPING A MAP REDUCE APPLICATION** Hadoop Operations: Cluster Specification, Cluster Setup and Installation, Hadoop Configuration, Security, Benchmarking a Hadoop Cluster. MapReduce Application: The Configuration API, Setting up the Development Environment, Writing a Unit Test With MRUnit, Running Locally on Test Data, Running on a Cluster, Tuning a Job, MapReduce Workflows.	12
UNIT – 3	**CLUSTER MANAGEMENT** Background, Spark Components-Driver, Workers and Executors, Configuration; Spark Standalone-Architecture, Single-Node Setup scenario, Multi Node Setup; YARN-Architecture, Dynamic Resource Allocation, Scenario; Mesos-Setup, Architecture, Dynamic Resource Allocation, Basic Setup Scenario.	12
UNIT – 4	**PERFORMANCE TUNING** Spark Execution Model, Partitioning, Shuffling Data – Shuffling and Data Partitioning, Operators and Shuffling; Serialization, Spark Cache, Memory Management, Shared Variables, Broadcast Variable, Accumulators; Data Locality.	12
UNIT – 5	**JOB EXECUTION AND FAULT TOLERANCE** **Job Execution:** Life Cycle of a Spark Job-Spark Master, Spark Driver, Spark Worker, Job Life Cycle; Job Scheduling- Scheduling Within an Application, Scheduling with External Utilities. **Fault Tolerance:** Fault Tolerance-Internal and External Fault Tolerance, Service Level Agreements, Resilient Distributed Datasets, Batch versus Streaming, Testing Strategies, Recommend Configurations.	12
	Total	60

Text Books:
1. Tom White, Hadoop:The Definitive Guide,O'Reilly,4th Edition,2015.
2. LlyaGanelin, EmaOr.hian, Kai Sasaki, Brennon York, Spark: Big Data Cluster Computing in Production,1st Edition,2016.

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Reference Books:
1. Nick Pentreath,Machine Learning with Spark,PacktPublishing,2015.
2. Mohammed Guller, Big Data Analytics with Spark, Apress,2015.
3. Donald Miner, Adam Shook, Map Reduce Design Pattern, O'Reilly, 2012
4. Frank J. Ohlhorst, Big Data Analytics: Turning Big Data into Big Money, Wiley Publication, December, 2012.
5. Kevin Roebuck, Big Data: High-Impact Strategies - What You Need to Know: Definitions, Adoptions, Impact, Benefits, Maturity, Vendors, Tebbo Publisher, 2011.
6. Alex Holmes, Hadoop in Practice, Manning Publications Publisher, 2012.

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I Semester	WEB ANALYTICS	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Introduce students to the fundamentals of web analytics, data collection methods, and tools used in analyzing web traffic and performance.
2. Provide hands-on knowledge about qualitative analysis and customer-centric strategies for improving website performance.
3. Familiarize students with various web analytics concepts such as search analytics, SEO, and PPC, and their role in improving website visibility.
4. Equip students with the skills required to implement goals and funnels, set up filters, and perform e-commerce tracking to enhance marketing strategies and attribution modeling.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand and implement basic web analytics tools and techniques	K2
CO2	Analyze customer behavior and create surveys for web-based user feedback	K3
CO3	Implement web analytics concepts like URLS, page views, and navigation reports.	K2
CO4	Set up and analyze goals and funnels, implement e-commerce tracking, and perform multi-channel attribution.	K3
CO5	Conduct search engine analytics and interpret customer behavior and campaign performance.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	L	M	L
CO2	M	M	H	H	M	M
CO3	M	M	M	M	H	M
CO4	M	M	H	H	H	M
CO5	M	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Web Analytics: Basics, Traditional Ways, Expectations, Data Collection, Clickstream Data, Weblogs, Beacons, JavaScript Tags, Packet Sniffing, Outcomes data, Competitive data, Search Engine Data.	12
UNIT – 2	Qualitative Analysis, Customer Centricity, Site Visits, Surveys, Questionnaires, Website Surveys, Post visits, Creating and Running, Benefits of surveys, Critical components of successful strategy.	12
UNIT – 3	Web Analytic concepts, URLS, Cookies, Time on site, Page views, Understand standard reports, Website content quality, Navigation reports (top pages, top destinations, site overlay). Search Analytics, Internal search,SEO and PPC, Measuring Email and Multichannel Marketing, Competitiveintelligence and Web 2.0 Analytics, Segmentation, Connectable reports.	12
UNIT – 4	Search Engine Analytics: Analytics, Cookies, Accounts vs Property, Tracking Code, Tracking Unique Visitors, Demographics, Page Views & Bounce Rate Acquisitions, Custom Reporting.	12
UNIT – 5	Goals & Funnels, Filters, Ecommerce Tracking, Real Time Reports, Customer Data Alert, AdWords Linking, AdSense Linking, Attribution Modelling, Segmentation, Campaign Tracking, Multi-Channel Attribution.	12
	Total	60

Text Books:
1. AvinashKaushik, "Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity", 1st Edition, Sybex, 2009.
2. Michael Beasley, "Practical Web Analytics for User Experience: How Analytics can help you Understand your Users", 1st Edition, Morgan Kaufmann, 2013.

Reference Books:
1. MagySeif El-Nasr, Anders Drachen, Alessandro Canossa, "Game Analytics: Maximizing the Value of Player Data", 1st Edition, Springer, 2013.
2. Bing Liu, "Web Data Mining: Exploring Hyperlinks, Content, and Usage Data", 2nd Edition, Springer, 2011.
3. Justin Cutroni, "Google Analytics", 1st Edition, O'Reilly, 2010.
4. Eric Fettman, Shiraz Asif, FerasAlhlou, "Google Analytics Breakthrough", John Wiley & sons, 2016.

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I Semester	INTELLIGENT SYSTEMS	L	T	P	C
		3	0	0	3

Course Objectives:

The main objectives of this course are to
1. Understand the fundamental concepts of knowledge representation and reasoning, including various knowledge representation models such as frames, semantic nets, and rules.
2. Learn about different rule-based systems, including forward and backward reasoning techniques, and their application in problem-solving through various search methods.
3. Gain proficiency in using tools like Lisp and Prolog for knowledge representation and reasoning, and understand how expert system shells can be developed and used in real-time applications.
4. Explore qualitative reasoning methods, such as qualitative simulation, and understand the application of Petri nets for intelligent control and system analysis.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Demonstrate the ability to represent and reason with data in various knowledge representation schemes like semantic nets, frames, and rules.	K3
CO2	Apply forward and backward reasoning techniques to solve real-world problems, and execute these methods through depth-first search, breadth-first search, and A* search.	K4
CO3	Develop knowledge-based systems using tools like Lisp and Prolog, and implement expert system shells for decision-making.	K5
CO4	Solve real-time system problems by designing intelligent subsystems and synchronizing them with real-time subsystems, using appropriate communication methods.	K4
CO5	Analyze and apply qualitative reasoning techniques like qualitative simulation and Petri nets for intelligent control and decision-making in dynamic systems.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	M	L	M	L	H
CO2	M	L	H	M	L	M
CO3	L	M	H	H	M	L
CO4	M	L	M	H	M	M
CO5	M	M	H	L	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**Knowledge Representation:** **Data and knowledge**: Data representation and data items in traditional databases, Data representation and data items in relational databases. Rules: Logical operations, Syntax and semantics of rules, Data log rule sets ,The dependence graph of data log rule sets, Objects Frames ,Semantic nets, Solving problems by reasoning: The structure of the knowledge base, The reasoning algorithm, Conflict resolution, Explanation of the reasoning.	12
UNIT – 2	**Rule Based Systems:** **Forward reasoning:** The method of forward reasoning, A simple case study of forward reasoning. **Backward reasoning:** Solving problems by reduction, The method of backward reasoning, A simple case study of backward reasoning, Bidirectional reasoning. Search Methods: Depth-first search, Breadth-first search, Hill climbing search, A* search. **Contradiction freeness:** The notion of contradiction freeness, Testing contradiction freeness, The search problem of contradiction freeness **Completeness:** The notion of completeness, Testing Completeness, The search problem of completeness .Decomposition of knowledge bases: Strict decomposition, Heuristic decomposition	12
UNIT – 3	**Tools for Representation and Reasoning:** **The Lisp programming language:** The fundamental data types in Lisp, Expressions and their evaluation, Some useful Lisp primitives, Some simple examples in Lisp, The Prolog programming **Language:** The elements of Prolog programs, The execution of Prolog programs, Built-in predicates, and Some simple examples in Prolog. Expert system shells: Components of an expert system shell, Basic functions and services in an expert system shell.	12
UNIT – 4	**Real-Time Expert Systems:** **The architecture of real-time expert systems**: The real-time subsystem, The intelligent subsystem. Synchronization and communication between real-time and intelligent subsystems:Synchronization and communication primitives, Priority handling and time-out. Data exchange between the real-time and the intelligent subsystems: Loose data exchange, The blackboardarchitecture. Software engineering of real-time expert systems: The software lifecycle of real-time expert systems, Special steps and tool, An Example of A Real-Time expert System.	12
UNIT – 5	**Qualitative Reasoning and Petri Nets:** Sign and interval calculus, Qualitative simulation: Constraint type	12

	qualitative differential equations, The solution of QDEs: the qualitative simulation algorithm: Initial data for the simulation, Steps of the simulation algorithm, Simulation results. Qualitative physics, Signed directed graph (SDG) models, The Notion of Petri nets, the firing of transitions, Special cases and extensions, the state-space of Petri nets the use of Petri nets for intelligent control, The analysis of Petri nets: Analysis Problems for Petri Nets, Analysis techniques.	
	Total	60

Text Books:

1. Intelligent Control Systems-An Introduction with Examples, Katalin M. Hangos, RozáliLakner , MiklósGerzson, Kluwer Academic Publishers.

References Books:

1. Intelligent Systems and Control: Principles and Applications Paperback, 12 Nov 2009, Laxmidhar Behera, IndraniKar by OXFORD.
2. Intelligent Systems and Technologies Methods and Applications, Springerpublications.
3. Intelligent Systems - Modeling, Optimization and Control, Yung C. Shin andChengyingXu, CRC Press, Taylor & Francis Group, 2009

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I Semester	ARTIFICIAL INTELLIGENCE LAB	L	T	P	C
		0	1	2	2

Course Objectives:
The objectives of this course are to
1. Understand and implement various search algorithms such as Depth-First Search (DFS), Breadth-First Search (BFS), A*, and Hill Climbing to solve different types of AI problems.
2. Develop problem-solving skills by implementing algorithms like Simulated Annealing, Traveling Salesman Problem, and the Wumpus World.
3. Implement classic AI problems such as the 8-puzzle, Tower of Hanoi, and Fibonacci series using suitable AI techniques and recursive approaches.
4. Understand and apply Expert Systems like JESS and RVD, along with logical programming (Prolog) for rule-based systems.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Apply search algorithms such as DFS, BFS, and A* to solve graph-based problems	K3
CO2	Implement optimization algorithms like Simulated Annealing and Hill Climbing to solve complex problems	K3
CO3	Develop solutions to classical AI problems such as the 8-puzzle, Tower of Hanoi, and Traveling Salesman Problem	K3
CO4	Develop and apply Expert Systems (like JESS and RVD) to real-world scenarios using rule-based reasoning	K4
CO5	Write and analyze logical programs using Prolog to perform tasks like arithmetic mean calculation and vowel checking	K2

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	L	H	L	M
CO2	H	M	L	H	L	M
CO3	H	L	L	H	L	M
CO4	M	H	M	M	L	M
CO5	M	L	L	H	L	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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WEEK	List of Experiments
1	1. Write a program to implementation of DFS 2. Write a program to implementation of BFS
2	1. Write a Program to find the solution for traveling salesman Problem
3	1. Write a program to implement Simulated Annealing Algorithm 2. Write a program to find the solution for wampus world problem
4	1. Write a program to implement 8 puzzle problem
5	1. Write a program to implement Tower of Hanoi problem
6	1. Write a program to implement A* Algorithm
7	1. Write a program to implement Hill Climbing Algorithm
8	1. Study JESS expert system
9	1. Write a Program to Perform Fibonacci Series 2. Write a Program to Check Sides of a Triangle
10	1. Write a Program to Perform Length of List 2. Write a Program to Perform Reverse in List.
11	1. Write a Prolog program to perform Arithmetic Mean. 2. Write a Program to Check Vowels or Not.

Text Books:
1. Stuart Russell, Peter Norvig, *Artificial Intelligence: A Modern Approach*, 3rd Edition, Pearson, 2010.
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, *Artificial Intelligence*, 3rd Edition, McGraw Hill, 2009.
3. Ivan Bratko, *Prolog Programming for Artificial Intelligence*, 4th Edition, Pearson, 2011.

Reference Books:
1. George F. Luger, *Artificial Intelligence: Structures and Strategies for Complex Problem Solving*, 6th Edition, Pearson, 2008.
2. Patrick Henry Winston, *LISP (3rd Edition)*, Addison-Wesley, 1996.
3. Jess in Action: Rule-Based Systems in Java, by Ernest Friedman-Hill, Manning Publications, 2003.
4. Nils J. Nilsson, *Artificial Intelligence: A New Synthesis*, Morgan Kaufmann, 1998.

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I Semester	DATA SCIENCE LAB	L	T	P	C
		0	1	2	2

Course Objectives:

The objectives of this course are to

1. Gain hands-on experience with NumPy for performing array computations and linear algebra operations, and applying random number generation.
2. Learn pandas for data manipulation, statistical analysis, and handling different data formats like CSV, JSON, and Excel files.
3. Practice data cleaning, preparation, and transformation, including missing data handling and text manipulation, using advanced pandas functions.
4. Explore and implement data wrangling, data visualization, and time series analysis using libraries like matplotlib and seaborn, along with advanced grouping and aggregation techniques.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Perform efficient array operations and linear algebra computations using NumPy, including random number generation for simulations	K3
CO2	Manipulate and analyze data using pandas, including data selection, cleaning, aggregation, and performing statistical analysis	K3
CO3	Demonstrate proficiency in data cleaning and preparation techniques, such as handling missing values, duplicates, and transforming datasets	K3
CO4	Visualize data using matplotlib and seaborn for effective communication of insights, and perform complex data wrangling tasks	K4
CO5	Perform time series analysis and implement perIod arithmetic, time zone manipulation, and frequency conversion using pandas	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	H	L	M
CO2	H	M	L	H	L	M
CO3	H	L	L	H	L	M
CO4	M	L	M	H	L	M
CO5	M	M	L	H	L	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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SNO	LIST OF EXERCISES

1	Array Computations using NumPy
	   a. Perform arithmetic operationsusing array.
	   b. Perform slicing and indexing on multi-dimensional arrays.
	   c. Perform computations on multi-dimensional array using universal functions (ufunc).
	   d. Compute arithmetic mean, standard deviation, variance, percentile, minimum and maximum, cumulative sum and product using statistical functions in NumPy.
	   e. Perform set theory operations such as union, intersection, symmetric difference and fetching unique values.

2	Linear Algebra and Random Number generation using linalg and random module in NumPy
	   a. Compute dot product, vector product and inner product of two arrays.
	   b. Perform matrix operations such as multiplication, determinant, sum of diagonal elements and inverse.
	   c. Compute eigenvalues, eigenvectors and singular value decomposition for a square matrix.
	   d. Generate random samples from uniform, normal, binomial, chi-square and Gaussian distributions using numpy.random functions.
	   e. Implement a single random walk with 1000 steps using random module and extract the statistics like minimum and maximum value along the walk's trajectory.

3	Data Manipulation using pandas
	   a. Create DataFrame from List, Dict, List of Dicts, Dicts of Series and perform operations such as column selection, addition, deletion and row selection,addition and deletion.
	   b. Create a DataFrame and perform descriptive statistics functions such as sum, mean, median, mode, standard deviation, skewness, kurtosis, cumulative sum, cumulative product and percent changes.
	   c. Implement the computation of correlation and covariance by considering the DataFrames of stock prices and volumes obtained from Yahoo Finance! Using pandas-data reader package.

4	Working with different data formats using pandas
	   a. Perform reading and writing data in text format using read_csv and read_table considering any online dataset in delimited format (CSV).
	   b. Perform reading, writing and parsing data in JSON (Javascript Object Notation) format using read_json.
	   c. Perform readingand writing of Microsoft Excel Files (xslx) using read_excel.

5	Interacting with Web APIs and Databases

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	a. Predict the last 30 GitHub issues for pandas using request and response object's json method. Move the extracted data to DataFrame and extract fields of interest. (Use url: 'https://api.github.com/repos/pandas-dev/pandas/issues') b. Connect to any relational database using corresponding SQL drivers and perform operations such as table creation, populating the table, selecting data from table, moving data from table to DataFrame, updating records and deleting records in a table.
6	Data Cleaning and Preparation a. Perform data cleaning by creating a DataFrame and identifying missing data using NA(Not Available) handling methods, filter out missing data using dropna function, fill the missing data using fillna function and remove duplicates using duplicated and drop_duplicates functions. b. Perform data transformation by modifying set of values using map and replace method and create transformed version of original dataset without modification using rename method. c. Create a DataFrame with normally distributed data using random sampling and detect possible outliers. d. Perform text manipulation with regular expression by applying relevant regular expression methods to split a string with a variable number of whitespace characters (tabs, spaces, and newlines) and get a list of all patterns matching.
7	Data Wrangling a. Perform hierarchical indexing by creating a series with a list of lists (or arrays) as the index, select subsets of data at outer and inner levels using partial indexing. b. Rearrange the tabular data with hierarchical indexing using unstack and stack method. c. Create two different DataFrames and merge them using index as merge key and combine data with overlap using combine_first method.
8	Perform Data Visualization with Matplotlib and SeaBorn considering online dataset for processing. a. Create a Line Plot by setting the title, axis labels, ticks, ticklabels , annotations on subplots and save to a file. b. Create Bar Plots using Series and DataFrame index. i. Create bar plotswith a DataFrame to group the values in each row together in a group in bars side by side for each value. ii. Create stacked bar plots from a DataFrame. c. Create Histogram to display the value frequency and Density Plot to generate continuous probability distribution function for observed data.

	d. Create Scatter Plot and examine the relationship between two one-dimensional data series.
	e. Create Box plots to visualize data with many categorical variables.
9	Data Aggregation
	a. Create a tabular dataset as a DataFrame and split data into groups using groupby method including single key and multiple key values. Select group by considering single and multiple columns.
	b. Compute summary statistics such as sum, mean and standard deviation for the grouped data using aggregate method.
	c. Use groupby function to split data into groups based on one column, miultiple columns, compute summary statistics and perform exploratory data analysis. Consider any online dataset for processing.
10	Time Series Analysis
	a. Create time series using datetime object in pandas indexed by timestamps.
	b. Use pandas.date_range to generate a DatetimeIndexwith an indicated length.
	c. Generate data ranges by setting time zone, localize time zone and convert to particular time zone using tz_convert and combine two different time zones.
	d. Perform period arithmetic such as adding and subtracting integers from periods and construct range of periods using period_range function.
	e. Convert Periods and Period Index objects to another frequency with as freqmethod.
	f. Convert Series and DataFrame objects indexed by timestamps to periods with the to_period method.

Text Books:
1.Wes McKinney, Python for Data Analysis, O'Reilly, 2nd Edition, 2017.
2.Alen B. Downey, Think Stats: Exploratory Data Analysis, O'Reilly Publications, 2nd Edition, 2015.

Reference Books:
1.SinanOzdemir, Principles of Data Science, Packt Publishers, 2nd Edition, 2018.

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II Semester	DEEP LEARNING	L	T	P	C
		3	1	0	4

Course Objectives:

The main objective of this course is to

1. Introduce the fundamental concepts of deep learning, including its history, foundational models (e.g., McCulloch-Pitts Neuron, Perceptrons), and the evolution of deep learning architectures.
2. Study optimization algorithms, activation functions, and regularization techniques used in deep learning models, ensuring effective training and generalization.
3. Understand and implement Convolutional Neural Networks (CNNs) and explore their applications in image processing tasks such as object detection and segmentation.
4. Dive into Recurrent Neural Networks (RNNs), sequence learning problems, LSTMs, GRUs, and explore advanced models such as attention mechanisms and graph neural networks (GNNs).

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Explain the history and evolution of deep learning models, including McCulloch-Pitts Neuron, Perceptrons, and Multi-layer Perceptrons (MLPs).	K2
CO2	Understand and implement key neural network architectures, including Feedforward Neural Networks (FFNs), Backpropagation, and the representation power of MLPs.	K3
CO3	Implement and apply various optimization algorithms such as Gradient Descent, Adam, and techniques like Xavier and He initialization for neural networks.	K3
CO4	Apply Convolutional Neural Networks (CNNs) for image-related tasks, including object detection, image segmentation, and advanced architectures like ResNet and GoogleNet.	K3
CO5	Design and implement Recurrent Neural Networks (RNNs) and advanced architectures like LSTMs, GRUs, and Encoder-Decoder models for sequence learning tasks.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	L	M	M
CO2	H	M	H	M	H	M
CO3	H	H	H	M	H	M
CO4	H	H	H	M	H	M
CO5	H	H	H	M	H	M

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(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	History of Deep Learning, McCulloch Pitts Neuron, Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons (MLPs), Representation Power of MLPs, Sigmoid Neurons, Gradient Descent, Feedforward Neural Networks (FFNs), Representation Power of FFNs, Backpropagation	12
UNIT – 2	Optimization algorithms and activation functions: Gradient Descent (GD), Momentum based GD, stochastic GD, mini-batch GD, Adagrad, RMSProp, Adam. Initialization techniques: Xavier and He initialization. Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Dropout, Batch Normalization	12
UNIT – 3	Convolutional Neural Networks (CNN): Convolution operation, filters, Padding and Stride, Sparse Connectivity and Weight Sharing, Max Pooling and NonLinearities. Transfer Learning and pretrained CNN architectures: AlexNet, ZFNet, VGGNet, GoogleNet, ResNet. Batch Normalization, Dropout.	12
UNIT – 4	Basic Concepts in Object Detection: Bounding box and annotation techniques, Non-maximum suppression (NMS), R-CNN and its evolution (Fast R-CNN, Faster R-CNN), You Only Look Once (YOLO) series, Single Shot MultiBox Detector (SSD) Semantic Segmentation, U-Net and its variants image segmentation, SegNet and its architecture, Instance and Panoptic Segmentation, Mask R-CNN for instance segmentation, Metrics for performance evaluation (mAP for detection, IoU for segmentation)	12
UNIT – 5	Recurrent Neural Networks (RNN): Sequence Learning problems, Intuition behind RNN, sequence classification, sequence labeling, Model, Loss function, Learning algorithm, Evaluation. Vanishing and Exploding gradient. LSTMs and GRUs, Encoder Decoder models, Attention mechanism, Graph Neural Networks (GNNs).	12
	Total	60

Text Books:
1. Bengio, Yoshua, Ian J. Goodfellow, and Aaron Courville. "Deep learning.", MIT Press(2015) .

Reference Books:
1. Bengio, Yoshua. "Learning deep architectures for AI." Foundations and trends in Machine Learning 2.1 (2009): 1127.
2. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. "O'Reilly Media, Inc.".
3. Trask, A. W. (2019). Groking deep learning. Simon and Schuster.

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II Semester	DATA VISUALIZATION	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Understand the fundamentals of data visualization, including its history, evolution, and relationship with other fields.
2. Explore the visual perception techniques and Gestalt principles that form the foundation of effective visualization design.
3. Develop skills in creating visual representations of various data types, including one-dimensional, two-dimensional, and multi-dimensional data, as well as more complex structures like trees, graphs, and networks.
4. Apply visualization techniques for real-world data, including time-series, volumetric data, geographical maps, and simulations, with a focus on interactive and collaborative visualizations.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Define and explain the history, purpose, and process of data visualization. Understand Gestalt principles and visual perception concepts to create meaningful visual representations of data.	K2
CO2	Design and implement effective one-dimensional, two-dimensional, and multi-dimensional data visualizations using appropriate visual mapping techniques.	K3
CO3	Analyze and visualize complex structures like trees, graphs, networks, and clusters, employing interaction techniques and visualization tools for detailed data exploration.	K5
CO4	Evaluate and interpret volumetric data, vector fields, and GIS systems, designing visualizations for collaborative analysis and data-driven decision-making.	K6
CO5	Critically assess recent visualization trends and perception techniques, identifying appropriate data structures for different visualization applications and optimizing them for clarity and impact.	K6

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	M
CO2	M	H	H	M	M	M
CO3	M	H	H	H	M	L
CO4	M	M	H	H	M	H
CO5	L	H	M	M	H	H

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**Introduction**: What Is Visualization?, History of Visualization, Relationship between Visualization and Other Fields. The Visualization Process, Introduction of visual perception, visual representation of data, Gestalt principles, and information overloads.	12
UNIT – 2	Creating visual representations, visualization reference model, visual mapping, visual analytics, Design of visualization applications	12
UNIT – 3	Classification of visualization systems, Interaction and visualization techniques misleading, Visualization of one, two and multi-dimensional data, text and text documents.	12
UNIT – 4	Visualization of groups, trees, graphs, clusters, networks, software, Metaphorical visualization	12
UNIT – 5	Visualization of volumetric data, vector fields, processes and simulations, Visualization of maps, geographic information, GIS systems, collaborative visualizations, Evaluating visualizations **Recent trends** in various perception techniques, various visualization techniques, data structures used in data visualization.	12
	Total	60

Text BookS:
1. WARD, GRINSTEIN, KEIM.Interactive Data Visualization: Foundations, Techniques, and Applications. Natick : A K Peters, Ltd.
2. E. Tufte, The Visual Display of Quantitative Information, Graphics Press.

E-Resources:
1. https://kdd.cs.ksu.edu/Courses/CIS536/Lectures/Slides/Lecture-34-Main_6up.pdf

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I Semester	FEATURE ENGINEERING FOR MACHINE LEARNING	L	T	P	C
		3	1	0	4

Course Objectives:

The objectives of this course are to

1. Introduce students to machine learning pipelines, data transformations (like log transformations and normalization), and techniques for processing text data, including feature extraction and parsing.
2. Explore various feature scaling techniques, including Term Frequency-Inverse Document Frequency (TF-IDF), and the application of logistic regression for classification.
3. Understand and apply techniques for dimensionality reduction, such as Principal Component Analysis (PCA), and explore non-linear featurization methods such as K-Means clustering and alternative dense featurization.
4. Develop an understanding of image feature extraction methods, including SIFT and HOG, and apply deep learning techniques, particularly convolutional neural networks (CNNs) for image feature extraction and classification tasks.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand and implement the machine learning pipeline, from data preprocessing (log transformations, scaling, feature selection) to text data transformation using techniques like bag-of-words and tokenization.	K2
CO2	Apply feature scaling techniques (e.g., TF-IDF), and implement logistic regression for classification, including regularization to improve model performance.	K3
CO3	Implement dimensionality reduction techniques like PCA and apply nonlinear featurization methods such as K-Means clustering to enhance model performance and feature representation.	K4
CO4	Develop image feature extraction pipelines using methods like SIFT and HOG, and implement deep learning techniques to extract and classify features from images using CNNs.	K5
CO5	Critically evaluate and compare different feature extraction and dimension reduction techniques to select the most effective ones for various types of data (text, numerical, and image data).	K6

#Based on suggested Revised BTL

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Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	M
CO2	M	H	H	M	M	L
CO3	M	H	H	M	M	M
CO4	M	M	H	H	H	M
CO5	L	H	M	M	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	**INTRODUCTION :** Machine Learning Pipeline, Scalars, Vectors, and Spaces, Log transformation, Feature Scaling or Normalization, Feature Selection, Text Data - Bag-of-X: Turning Natural Text into Flat Vectors, Filtering for Cleaner Features, Parsing and Tokenization, Collocation Extraction for Phrase Detection.	12
UNIT – 2	**FEATURE SCALING :** Term Frequency & Inverse Document frequency, Scaling Bag-of-Words with Tf-Idf Transformation, Classification with Logistic Regression, Tuning Logistic Regression with Regularization, Encoding Categorical Variables, Feature Hashing, Bin Counting.	12
UNIT – 3	**DIMENSIONALITY REDUCTION :** Intuition, Derivation, Linear Projection, Variance and Empirical Variance, Principal Components: First Formulation, Principal Components: Matrix-Vector Formulation, General Solution of the Principal Components, Transforming Features, Whitening and ZCA, Considerations and Limitations of PCA**.**	12
UNIT – 4	**NONLINEAR FEATURIZATION :** K-Means Clustering, Clustering as Surface Tiling, k-Means, Featurization for Classification, Alternative Dense Featurization.	12
UNIT – 5	**IMAGE FEATURE EXTRACTION AND DEEP LEARNING :** Feature Extraction- SIFT and HOG, Image Gradients, Gradient Orientation Histograms, SIFT Architecture; Learning Image Features with Deep Neural Networks -Fully Connected Layers, Convolutional Layers;	12
	Total	60

Text Books:
1. Alice Zheng, Amanda Casari,Feature Engineering for Machine Learning, O'Reilly Media, Inc. (ISBN: 9781491953242), 2018.
2. Kjell Johnson and Max Kuhn , Feature Engineering and Selection: A Practical Approach for Predictive Models, CRC Press, 2020.

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II Semester	**FUZZY LOGIC AND FUZZY SETS**	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Introduce students to the fundamental concepts of fuzzy sets, fuzzy logic, and classical set theory, along with understanding the difference between crisp and fuzzy sets and their applications in dealing with uncertainty and imprecision.
2. Explore various operations on fuzzy sets, including fuzzy complements, t-norms, and aggregation operations, and apply them in fuzzy systems and decision-making processes.
3. Provide an in-depth understanding of fuzzy logic systems and models, including Mamdani, Sugeno, and Tsukamoto fuzzy models, and the application of fuzzy inference in real-world problems.
4. Teach students the inference mechanisms used in fuzzy systems, including conditional fuzzy propositions, fuzzy quantifiers, and input space partitioning, enabling them to develop and implement fuzzy-based decision systems.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand and explain the basic concepts of fuzzy sets, their differences from crisp sets, and alpha-cuts.	K2
CO2	Apply operations on fuzzy sets, including fuzzy complements, t-norms, and aggregation operations, in problem-solving scenarios.	K3
CO3	Design and implement fuzzy inference systems using Mamdani, Sugeno, and Tsukamoto fuzzy models, and evaluate their performance.	K4
CO4	Implement and evaluate inference mechanisms for fuzzy propositions, fuzzy quantifiers, and multi-valued logic.	K5
CO5	Develop and simulate fuzzy models for real-world applications, employing input space partitioning and fuzzy decision-making methods.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	M
CO2	M	H	H	M	M	L
CO3	M	H	H	M	M	M
CO4	M	H	M	M	H	M
CO5	M	M	H	H	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Fuzzy Set: Introduction, uncertainty, Newtonian mechanics, Probability Theory, organized simplicity, disorganized complexity, trans computational problems.	12
UNIT – 2	Crisp Sets: An overview, fuzzy sets: Basic types, basic concepts. Fuzzy sets versus crisp sets, additional properties of alpha-cuts, representations of fuzzy sets.	12
UNIT – 3	Operations on Fuzzy sets: Types of operations, fuzzy complements, Fuzzy instructions: t-Norms. Fuzzy Unicons: t-co norms, combination of operations, aggregation operations.	12
UNIT – 4	Fuzzy Logic: Classical logic, logic, reasoning, propositional logic, logic operation's logic formulas, tautology, inference rules, Boolean algebra, properties of Boolean algebra, quantification, predicate logic, multi-valued logic, fuzzy propositions, fuzzy quantifiers, linguistic hedges.	12
UNIT – 5	Inference from conditional Fuzzy propositions, Inference from conditional and quantified propositions. Mamdani fuzzy models, Sugeno Fuzzy Models, Tsukamoto Fuzzy Model, Input space partitioning, Fuzzy modelling.	12
	Total	60

Textbooks:
1. Li Min Fu," *Neural Networks in Computer Intelligence*", 1st Edition, McGraw-Hill, Inc,1994.
2. George J Klir/Bo Yuan, "*Fuzzy sets & Fuzzy Logic, Theory & Applications*", 1st Edition, PHI, 2015.
3. S.R. Jang, C.T. Sun, E. Mizutani. "*Neuro Fuzzy & Soft Computing: A Computational approach to learning & Machine Intelligence*" J Pearson Education, 1996.

Reference Books:
1. Lotfi A. Zadeh and George J. Klir, Fuzzy Sets, Fuzzy Logic, and Fuzzy Systems: Selected Papers by Lotfi A. Zadeh, World Scientific Publishing, 1996.
2. Timothy J. Ross, Fuzzy Logic with Engineering Applications, 4th Edition, Wiley, 2020.
3. Hans Bandemer and Siegfried Gottwald, Fuzzy Sets, Fuzzy Logic, Fuzzy Methods with Applications, Wiley, 1995.
4. Didier Dubois and Henri Prade, Fundamentals of Fuzzy Sets, Springer, 2000.
5. Krassimir T. Atanassov, Intuitionistic Fuzzy Sets: Theory and Applications, Springer, 1999.

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II Semester	SOCIAL NETWORKING AND MINING	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Introduce students to the fundamental concepts of the Semantic Web, Social Web, and Social Network Analysis (SNA), and understand the limitations of the current web.
2. Develop students' skills in visualizing social networks using various techniques like Node-Link Diagrams, Matrix-Based Representations, and Hybrid Representations, and analyze key metrics like centrality and clustering.
3. Explore techniques for community detection and mining social networks, including node classification, evolution of web communities, and evaluating mining algorithms.
4. Enable students to perform text and opinion mining in social networks, focusing on sentiment analysis, opinion extraction, and tracking sentiment over time, using modern tools and techniques.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the limitations of the current web, the development of the Semantic Web, and the emergence of social networks	K2
CO2	Apply techniques for visualizing social networks, including graph representations, centrality, clustering, and matrix-based visualizations.	K4
CO3	Perform community detection and classification in social networks, and evaluate the effectiveness of community mining algorithms.	K5
CO4	Implement text mining techniques to extract opinions, perform sentiment classification, and track sentiment over time in social network data	K5
CO5	Use tools like UCINET, Pajek, NodeXL, and others for real-world social network analysis.	K6

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	M	L	M
CO2	M	H	M	M	M	M
CO3	M	H	H	M	L	M
CO4	M	M	H	M	H	M
CO5	M	M	M	M	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Introduction- Introduction to Web - Limitations of current Web, Development of Semantic Web, Emergence of the Social Web, Statistical Properties of Social Networks, Network analysis, Development of Social Network Analysis, Key concepts and measures in network analysis, Discussion networks, Blogs and online communities, Web-based networks.	12
UNIT – 2	Modelling and Visualization- Visualizing Online Social Networks, A Taxonomy of 26 Visualizations, Graph Representation, Centrality, Clustering, Node-EdgEVisualizing Social Networks with Matrix-Based Representations, Node-Link Diagrams, Hybrid Representations, Modelling and aggregating social network data, Random Walks and their Applications, Use of Hadoop and Map Reduce - Ontological representation of social individuals and relationships.	12
UNIT – 3	Mining Communities- Aggregating and reasoning with social network data, Advanced Representations, Extracting evolution of Web Community from a Series of Web Archive, Detecting Communities in Social Networks, Evaluating Communities, Core Methods for Community Detection & Mining, Applications of Community Mining Algorithms, Node Classification in Social Networks.	12
UNIT – 4	Text and Opinion Mining- Text Mining in Social Networks, Opinion extraction, Sentiment classification and clustering, Temporal sentiment analysis, Irony detection in opinion mining, Wish analysis, Product review mining, Review Classification, Tracking sentiments towards topics over time.	12
UNIT – 5	Tools for Social Network Analysis- UCINET, PAJEK, ETDRAW, StOCNET, Splus, R, NodeXL, SIENA and RSIENA - Real world Social Networks (Facebook- Twitter etc.).	12
	Total	60

Textbooks:
1. Charu C. Aggarwal, "*Social Network Data Analytics*", Springer, 2011.
2. Peter Mika, "*Social Networks and the Semantic Web*", 1st Edition, Springer, 2007.
3. BorkoFurht, "*Handbook of Social Network Technologies and Applications*", 1st Edition, Springer,2010.

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Reference Books:

1. GuandongXu, Yanchun Zhang and Lin Li, "*Web Mining and Social Networking - Techniques and Applications*", 1st Edition, Springer, 2011.
2. Giles, Mark Smith, John Yen, "*Advances in Social Network Mining and Analysis*", Springer, 2010.
3. Ajith Abraham, Aboul Ella Hassanien, VáclavSnáel, "*Computational Social Network Analysis: Trends, Tools and Research Advances*", Springer, 2009.
4. SuleGündüz-Ogüdücü, A. ŞimaEtaner-Uyar, "*Social Networks: Analysis and Case Studies*", Springer, 2014.

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II Semester	DATA PREPARATION AND ANALYSIS	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Introduce students to the fundamental concepts of data gathering, data formats, parsing, and transformation, as well as address challenges in scalability and real-time data issues.
2. Equip students with the skills required for data cleaning, including techniques for handling inconsistent, heterogeneous, and missing data, and performing data transformation and segmentation.
3. Enable students to conduct exploratory data analysis (EDA) by applying descriptive and comparative statistics, clustering, association techniques, and generating hypotheses from the data.
4. Provide hands-on experience in developing interactive visualizations and analyze real-world datasets using R or Python.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the concepts and techniques of data gathering and data preparation, including handling different data formats, parsing, and transformation.	K2
CO2	Perform data cleaning by addressing inconsistent, heterogeneous, and missing data, and apply techniques for data transformation and segmentation.	K4
CO3	Conduct exploratory data analysis using descriptive statistics, comparative statistics, clustering, association techniques, and generate hypotheses for deeper data insights.	K3
CO4	Design and implement effective visualizations for diverse data types, including time series, geolocated data, hierarchies, and networks using tools like R and Python.	K4
CO5	Develop interactive visualizations using R or Python and apply them to solve complex data problems, enhancing understanding through user interaction.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	L	L	L	M
CO2	M	H	M	L	M	M
CO3	M	H	H	M	M	L
CO4	M	M	M	H	H	M
CO5	M	M	M	M	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Data Gathering and Preparation: Data formats, parsing and transformation, Scalability and real-time issues.	12
UNIT – 2	Data Cleaning: Consistency checking, Heterogeneous and missing data, Data Transformation and segmentation.	12
UNIT – 3	Exploratory Analysis: Descriptive and comparative statistics, Clustering and association, Hypothesis generation.	12
UNIT – 4	Visualization: Designing visualizations, Time series, Geolocated data, Correlations and connections, Hierarchies and networks, interactivity.	12
UNIT – 5	Visualizations using R or Python.	12
	Total	60

Textbooks:

1. Glenn J. Myatt, "*Making sense of Data: A practical Guide to Exploratory Data Analysis and Data Mining*", 2nd Edition, John Wiley Publishers, 2014.

Reference Books:

2. Ben Fry, Visualizing Data: Exploring and Explaining Data with the Processing Environment, O'Reilly Media, 2008.
3. Nathan Yau, Data Points: Visualization That Means Something, Wiley, 2013.

II Semester	**SCALABLE SYSTEMS FOR DATA SCIENCE**	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Understand the principles and techniques of data mining, including key algorithms for clustering, association, and anomaly detection.
2. Learn and implement MapReduce and parallel processing techniques for large-scale data analysis.
3. Explore and apply different methods for data stream mining, similarity search, and locality-sensitive hashing.
4. Develop hands-on skills in clustering, recommendation systems, and large-scale machine learning using techniques like dimensionality reduction and support vector machines (SVM).

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Demonstrate an understanding of data mining concepts, including key algorithms such as A-Priori, clustering methods, and hash functions for indexing.	K2
CO2	Implement MapReduce and parallel processing techniques for analyzing large-scale datasets efficiently.	K3
CO3	Apply clustering techniques like k-means and hierarchical clustering to group and categorize data, including handling non-Euclidean spaces.	K3
CO4	Develop recommendation systems using content-based filtering and collaborative filtering techniques, and understand dimensionality reduction methods.	K4
CO5	Gain hands-on experience with large-scale machine learning models such as perceptrons and SVM, and understand how to implement them in distributed systems.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	L	H	M	L
CO2	M	M	H	H	H	M
CO3	M	H	M	M	H	M
CO4	M	M	H	H	H	M
CO5	H	M	H	H	M	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	Overview of Data Mining and map-reduce, Hash Functions - Indexes, Shingling LSH, Mining Data Streams - Finding similar items near-neighbor search, shingling of documents, Similarity-Preserving Summaries of Sets, Locality-Sensitive Hashing for Documents, Distance Measures, Link-analysis Page Rank, Link spam, Hubs and authorities.	12
UNIT – 2	Frequent Item sets Market based model, A-Priori Algorithm, Handling larger data sets in memory, Limited-pass algorithms.	12
UNIT – 3	Clustering Hierarchical clustering, k-means, CURE, Clustering in Non-Euclidean Spaces, Clustering for Streams and Parallelism.	12
UNIT – 4	Advertising on the web Matching problem, ad-words problem, Recommendation systems - Content-Based Recommendations, Collaborative Filtering, Dimensionality Reduction.	12
UNIT – 5	Large-scale machine learning Parallel Implementation of Perceptrons, Parallel implementation of SVM, Dealing with High-Dimensional Euclidean Data in nearest neighbors, Distributed machine learning.	12
	Total	60

Text Books:

1. Jure Leskovec, AnandRajaraman, Jerey David Ullman, "*Mining of Massive Datasets*", Cambridge University Press, 2014.
2. Jimmy Lin and Chris Dyer, "*Data-Intensive Text Processing with MapReduce*", 1st Edition, Morgan and Claypool Publishers, 2010.

Reference Books:

1. Sandy Ryza, Uri Laserson, Sean Owen, Josh Wills, "*Advanced Analytics with Spark: Patterns for Learning from Data at Scale*", Oreilly, 2015.
2. Ankit Jain, "*Mastering Apache Storm: Processing big data streaming in real time*", Packt Publishing, 2017.

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II Semester	BUSINESS INTELLIGENCE TOOLS	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Understand the foundations of Business Intelligence (BI) and its role in decision making, including its concepts, benefits, and characteristics.
2. Gain knowledge of data modeling techniques for BI solutions, including business, logical, dimensional, and physical modeling.
3. Learn about the ETL (Extract, Transform, Load) process and its optimization in BI systems.
4. Explore the different aspects of business reporting, performance management, and the use of BI tools for effective decision support.
5. Understand the transition of BI processes to a product environment, including deployment, maintenance, and security in cloud-based BI solutions.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Explain the core concepts, characteristics, benefits, and components of Business Intelligence systems.	K2
CO2	Model data for BI solutions using various models like Business, Logical, Dimensional, and Physical models	K3
CO3	Design and implement ETL workflows for efficient data integration and optimization	K3
CO4	Generate meaningful business reports and utilize BI tools for data visualization and performance management	K4
CO5	Understand how to move BI processes to a cloud environment and maintain the system effectively in different environments.	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	L	M	M	L
CO2	H	M	H	M	M	L
CO3	M	M	H	H	M	M
CO4	M	H	M	H	H	M
CO5	H	M	H	M	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**FOUNDATIONS OF BUSINESS INTELLIGENCE AND DECISION MAKING** Foundations of Business Intelligence: What Is business intelligence?, BI Characteristics, Benefits of BI, BI Platform Components, BI Platform Location, BI Concepts,BI Approaches, BI Capabilities. Decision Making: Introduction and Definitions, Phases of the Decision-Making Process, The Intelligence Phase, The Design Phase, The Choice Phase, The Implementation Phase, Support for various phases, Decision Support Systems: Capabilities, DSS Classifications, Components of Decision Support Systems.	12
UNIT – 2	**DATA MODELING FOR BI SOLUTIONS** Modeling steps- Business Model, Logical Model, Dimensional Model, Physical Model;Defining our Model-Sales Dimension, Status Table, Currency Dimension, Customer Dimension, Employee Dimension, Product Dimension, and Time Dimension; Exploring Data Modeling Possibilities, Data Modeling Tools: Preparing the ETL- Source Systems, Source Tables, Source Fields.	12
UNIT – 3	**ETL BASICS AND OPTIMIZATIONS** Details of the Solution, Open Source ETL Suites, Downloading and Installing Pentaho Data Integration. Understanding ETL Concepts-Repositories and Connections, Transformations, How to Organize a Set of Transformations in a Workflow, Create and Share a Connection, The Global Picture, The Product Parent Category Tables, The Customer and Customer Country Tables, The Employee and Employee Category and Employee Department Tables, The Fact Table, Creating the Time Dimension, Connecting All of It Up, Designing the Job Open Source Alternatives to PDI;ETL Optimizations.	12
UNIT – 4	**BUSINESS REPORTING, AND PERFORMANCE MANAGEMENT** **Business Reporting**: Business Reporting Definitions and Concepts, Data and Information Visualization, Different Types of Charts and Graphs, The Emergence of Data Visualization and Visual Analytics, BI Tools: Microstrategy Desktop-Tableau, Microsoft Power BI, Qlik Sense. **Performance Management:** Performance Dashboards, Closed-Loop BPM Cycle, Performance Measurement, Key Performance Indicator, Balanced Scorecards, Six Sigma as a Performance Measurement System.	12
UNIT – 5	**MOVING BI PROCESS TO PRODUCT ENVIRONMENT**	12

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	Multi environment Scenario-Deploying a Productive Environment, Adding Environments, Isolation of Environments, Multi environment Recommendations; Maintaining Your Environment, Security, Auditing, Moving BI Processes to the Cloud- Deciding our Cloud Provider, Choosing the Right Cloud Provider: Amazon Web Services (AWS), Microsoft Azure, Google Cloud, Vendor-Based Cloud Solutions.	
	Total	60

Text Books:
1. Albert Nogus, Juan Valladaraes, Business Intelligence Tools for Small Companies, Apress, Tenth Edition 2017.
2. ChandraishSinha, Mastering PowerBI, BpB Publications,2022.

Reference Books:
1. Ramesh Sharda, DursunDelen, Efraim Turban, Business Intelligence and Analytics, Pearson, 10th Edition,2014.
2. Hancoc,;Toren, Practical Business Intelligence with SQL Server 2005, Pearson,2022.

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II Semester	DATA ENGINEERING	L	T	P	C
		3	0	0	3

Course Objectives:

The objectives of this course are to

1. Understand the core concepts and capabilities of modern data engineering, including cloud computing, data lakes, and data storytelling.
2. Explore the structure and architecture of data lakes and data pipelines, focusing on storage, compute resources, and compliance frameworks.
3. Learn how to create and implement data curation pipelines, understand Delta Lake, and perform data transformations.
4. Develop data aggregation pipelines, understand the gold layer, and ensure data verification and proper data consumption.
5. Address the challenges in data engineering, including deployment, monitoring, and managing data pipelines in production environments.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Understand the core capabilities of data storage and compute resources, the role of cloud computing in data engineering, and how data storytelling influences decision making.	K2
CO2	Design and implement data lakes, segregate storage and compute, and adhere to compliance frameworks while understanding the CAP theorem.	K3
CO3	Build and run data pipelines, understand different data collection stages, and design ingestion pipelines for raw data collection.	K3
CO4	Implement data curation pipelines, utilize Delta Lake for time travel and upserts, and curate raw data into a usable silver layer.	K3
CO5	Aggregate data effectively, build and run aggregation pipelines, verify aggregated data in the gold layer, and monitor and deploy pipelines in production environments.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	L	M	M	L
CO2	H	M	H	M	M	M
CO3	M	M	H	M	M	L
CO4	M	M	H	H	M	M
CO5	H	M	H	M	H	H

(Please fill the above with Levels of Correlation, viz., L, M, H)

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UNIT	CONTENTS	Contact Hours
UNIT – 1	**MODERN DATA ENGINEERING AND TOOLS** Data Engineering and Analytics: Core capabilities of storage and compute resources, Availability of varying datasets, Computing Adoption of cloud computing, Data storytelling, The monetary power of data. Discovering Storage and Compute Data Lakes: Exploring the benefits of data lakes, Adhering to compliance frameworks, Segregating storage and compute in a data lake, Discovering data lake Architectures, The CAP theorem.	12
UNIT – 2	**DATA PIPELINES AND DATA COLLECTION STAGE** Understanding Data Pipelines: Components of a data pipeline, Process of creating a data pipeline, Running a data pipeline Data Collection Stage: Architecting the Electroniz data lake, Understanding the bronze layer, Configuring data sources, Configuring data destinations, Building the ingestion pipelines.	12
UNIT – 3	**DATA CURATION STAGE** Understanding Delta Lake: Understanding Delta Lake, Creating a Delta Lake table, Changing data in an existing Delta Lake table, Performing time travel, Performingupserts of data, Understanding isolation levels, Understanding concurrency control. Data Curation Stage: The need for curating raw data, The process of curating raw data, Developing a data curation pipeline, Running the pipeline for the silver layer, Verifying curated data in the silver layer.	12
UNIT – 4	**DATA AGGREGATION STAGE** The need to aggregate data, The process of aggregating data, Developing a data aggregation pipeline, Running the aggregation pipeline, Understanding data consumption, Verifying aggregated data in the gold layer.	12
UNIT – 5	**DATA ENGINEERING CHALLENGES AND EFFECTIVE DEPLOYMENT STRATEGIES** Deploying and Monitoring Pipelines in Production: The deployment strategy, Developing the master pipeline, Testing the master pipeline, Scheduling the master pipeline, Monitoring pipelines. Solving Data Engineering Challenges: Schema evolution, Sharing data, Data governance.	12
	Total	60

Text Books:

1. ManojKukreja, DanilZburivsky, Data Engineering with Apache Spark, Delta Lake, and Lakehouse: Create Scalable Pipelines that Ingest, Curate, and Aggregate Complex Data in a Timely and Secure Way, Packt Publishing, 2021.
2. Crickard, Paul, Data Engineering with Python: Work with Massive Datasets to Design Data Models and Automate Data Pipelines Using Python, Packt Publishing, 2020.

Reference Books:

1. Eagar, G, Data Engineering with AWS: Learn how to Design and Build Cloud-based Data Transformation Pipelines Using AWS, Packt Publishing, 2021.
2. Housley, Matt, and Reis, Joe, Fundamentals of Data Engineering: Plan and Build Robust Data Systems, O'Reilly Media, Incorporated, 2022.

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II Semester	DEEP LEARNING LAB	L	T	P	C
		0	1	2	2

Course Objectives:
The main objective of this course is to
1. Learn how to implement and optimize basic machine learning models like gradient descent and neural networks from scratch to minimize a cost function.
2. Gain practical experience in building and training Convolutional Neural Networks (CNNs) for image classification and Recurrent Neural Networks (RNNs) for sequential data analysis.
3. Learn how to use pre-trained models and fine-tune them for new tasks, and understand how advanced deep learning architectures (like GANs and GNNs) work.
4. Implement deep learning solutions for tasks such as sentiment analysis, stock price prediction, and language detection, applying data augmentation and advanced techniques for improving model performance.

Course Outcomes: At the end of the course, student will be able to

		Knowledge Level (K)#
CO1	Implement basic machine learning algorithms, including gradient descent and neural network optimization, from scratch to minimize cost functions.	K3
CO2	Build and train Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) using TensorFlow and PyTorch for image classification and sequential data prediction tasks.	K3
CO3	Apply transfer learning with pre-trained models such as VGG16, ResNet, and MobileNet to solve image classification problems.	K4
CO4	Develop Generative Adversarial Networks (GANs) to generate synthetic data and solve image generation tasks.	K5
CO5	Solve real-world problems in NLP (Sentiment Analysis), time-series forecasting (Stock Prediction), and language detection using neural networks and advanced deep learning techniques.	K3

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	M	L	L	L
CO2	H	M	M	H	M	M
CO3	M	M	H	M	M	M
CO4	M	H	L	H	L	L
CO5	M	M	H	H	H	H

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Experiments	CONTENTS
Week 1	**Implementing Gradient Descent Algorithm from Scratch** **Objective:** Understand and implement the gradient descent optimization algorithm to minimize a simple cost function.
Week– 2	**Data Preprocessing** **Objective:** Load, reshape, normalize, and preprocess data for a neural network model. This includes converting labels to one-hot encoding
Week– 3	**Building and Training Neural Networks using Tensorflow** **Objective:** Build, train, validate, and infer with a neural network using Keras, and learn to save and reload the model
Week– 4	**Building and Training Neural Networks using PyTorch** **Objective:** Build, train, validate, and infer with a neural network using PyTorch, and learn to save and reload the model
Week– 5	**Binary Classification of Images** **Objective:** Create a CNN that can differentiate between cat and dog images. **Dataset:** Cats vs. Dogs Dataset (commonly found on Kaggle)
Week-6	**Multiclass Classification of Images** **Objective:** Build a simple convolutional neural network (CNN) to classify images Datasets: MNIST, Fashion-MNIST and CIFAR-10
Week 7	**Implementing Data Augmentation** **Objective:** Apply data augmentation techniques to enhance the training dataset for a neural network, improving model robustness and helping prevent overfitting.
Week– 8	**Transfer Learning for Image Classification** **Objective:** Utilize a pre-trained model (like VGG16, ResNet, or MobileNet) as a feature extractor and fine-tune it to classify a new set of images. **Dataset:** Use the Oxford 102 Flowers dataset for flower classification or the Stanford Cars dataset for car classification.
Week– 9	**Sentiment Analysis** **Objective:** Train a neural network to classify movie reviews from the IMDB dataset as positive or negative. **Dataset:** IMDB Movie Reviews
Week– 10	**Stock Prices Prediction** **Objective:** Build a model using RNNs to predict future stock prices based on historical price data. **Dataset:** Any stock price historical data
Week– 11	**Language Detection** **Objective:** Train a neural network to detect the language of a given text snippet. **Dataset:** WiLI-2018, a benchmark dataset for language identification

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Week-12	**Generative Adversarial Network (GAN)** **Objective:** Generate digits by training a GAN on Identify the Digits (MNIST) dataset
Week-13	**Graph Neural Network (GNN)** **Objective:** Implement and explore basic Graph Neural Network (GNN) architectures to solve problems related to molecular data **Dataset:** Molecule Net (Tox-21)

Text Books:
1. Chollet, François. "Deep Learning with Python, " Manning Publications, 2017.

Reference Books:

1. Deep Learning by Ian Goodfellow, YoshuaBengio and Aaron Courville, MIT Press.
2. The Elements of Statistical Learning by T. Hastie, R. Tibshirani, J. Friedman, Springer.
3. Probabilistic Graphical Models. Koller, N. Friedman, MIT Press.

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II Semester	DATA VISUALIZATION LAB	L	T	P	C
		0	1	2	2

Course Objectives:

The objectives of this course are to

1. Understanding Data Visualization Techniques: Equip students with the skills to use various R packages for visualizing datasets, including histograms, scatter plots, and heat maps.
2. Exploring Data Structures in R: Introduce students to the structure of various datasets (e.g., VADeaths, AirQuality, Iris, Diamonds) and how to manipulate them in R for effective visualization.
3. Advanced Visualizations: Enable students to generate advanced visualizations such as 3D graphs, correlograms, and maps to present multidimensional data.
4. Hands-On Practice with R Libraries: Familiarize students with R libraries such as ggplot2, leaflet, maps, and hexbin for data visualization, along with installation, manipulation, and visualization of large datasets.

Course Outcomes: On completion of this course, the student will be able to:

		Knowledge Level (K)#
CO1	Demonstrate the ability to load, explore, and visualize datasets using basic charts such as histograms, bar charts, and line charts.	K2
CO2	Analyze and visualize multidimensional data using advanced visualization techniques such as scatter plots, box plots, and hexbin plots in R.	K3
CO3	Implement and visualize correlation matrices and perform data aggregation using advanced tools such as correlogram and heatmap.	K3
CO4	Utilize interactive data visualizations through R libraries like leaflet and maps to represent geographical and spatial data effectively.	K4
CO5	Develop proficiency in handling large datasets, such as the Diamonds dataset, and visualizing categorical and continuous data through complex visualizations.	K4

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	M	H	L	M
CO2	M	H	M	H	M	M
CO3	M	M	M	H	M	L
CO4	L	M	L	H	M	M
CO5	M	M	H	M	H	M

(Please fill the above with Levels of Correlation, viz., L, M, H)

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SNO	List of Experiments
1	a) Load VADeaths(Death Rates in Virginia)dataset in R and visualize the data using different histograms. b) Load air quality dataset in R and visualize La Guardia Airport's dialy maximum temperature using histogram.
2	Load AirPassengers dataset in R and visualize the data using line chart that shows increase in air passengers over given time period.
3	a) Load iris dataset in R, visualize the data using different Bar Charts and also demonstrate the use of stacked plots. b) Load air quality dataset in R and visualize ozone concentration in air.
4	a) Load iris dataset in R, visualize the data using different Box plots including group by option and also use color palette to represent species. b) Load air quality dataset in R and visualize air quality parameters using box plots.
5	Visualize iris dataset using simple scatter, multivariate scatter plot and also visualize scatter plot matrix to visualize multiple variables across each other.
6	Load diamonds dataset in R and visualize the structure in datasets with large data points using hexagon binning and also add color palette then use the
7	Load HairEyeColor dataset in R and plot categorical data using mosaic plot.
8	Load mtcars dataset in R and visualize data using heat map.
9	Install leaflet library in R and perform different map visualizations.
10	Visualize iris dataset using 3d graphs such as scatter3d, cloud, xyplot.
11	Make use of correlogram to visualize data in correlation matrices for iris dataset.
12	Install maps library in R and draw different map visualizations.

Web References:
1. https://www.analyticsvidhya.com/blog/2015/07/guide-data-visualization-r/
2. https://www.geeksforgeeks.org/data-visualization-in-r/

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III Semester	RESEARCH METHODOLOGY AND IPR	L	T	P	C
		3	0	0	3

Course Objectives:

1. Students will be able to define what constitutes a research problem by identifying gaps, inconsistencies, or limitations in existing knowledge.

2. Students will conduct comprehensive literature reviews to pinpoint unresolved issues or future research directions, synthesizing information to formulate clear research questions.

3.Students will demonstrate the ability to convert broad topics or practical concerns into focused, manageable, and empirically investigable research problems

Course Outcomes: At the end of the course, student will be able to (Four to Six)

		Knowledge Level (K)#
CO1	*Identify and formulate research problems, design investigative approaches, and apply appropriate data collection and analysis methods.*	K2
CO2	*Conduct effective literature reviews, maintain research ethics, and prepare structured technical reports and research proposals.*	K3
CO3	*Explain the nature and types of Intellectual Property Rights and processes for patenting innovations nationally and internationally.*	K2
CO4	*Analyze patent rights, licensing processes, technology transfer, and the use of patent databases.*	K4
CO5	*Evaluate recent developments in IPR, including biological systems, software, and traditional knowledge through case studies.*	K5

#Based on suggested Revised BTL

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H		M			
CO2		H				
CO3			M			M
CO4			M			M
CO5			M			M
CO6						

(Please fill the above with Levels of Correlation, viz., L, M, H)

UNIT	CONTENTS	Contact Hours
UNIT – 1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.	12

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	Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	
UNIT – 2	Effective literature studies approaches, analysis Plagiarism, Research ethics, Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	12
UNIT – 3	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT	12
UNIT – 4	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	12
UNIT – 5	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs	12
	Total	60

REFERENCES:

(1) Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
(2) Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
(3) Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners"
(4) Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
(5) Mayall, "Industrial Design", McGraw Hill, 1992.
(6) Niebel, "Product Design", McGraw Hill, 1974.
(7) Asimov, "Introduction to Design", Prentice Hall, 1962.
(8) Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in NewTechnological Age", 2016.T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008.