माधव प्रौद्योगिकी एवं विज्ञान संस्थान, ग्वालियर (म.प्र.), भारत
MADHAV INSTITUTE OF TECHNOLOGY & SCIENCE, GWALIOR (M.P.), INDIA
Deemed University
(Declared under Distinct Category by Ministry of Education, Government of India)
NAAC ACCREDITED WITH A++ GRADE

Centre for Artificial Intelligence

ANNEXURE-VIII

Syllabi (along with Experiment List)
of
Departmental Core Courses (DC)
of
B. Tech. V Semester
[Information Technology (Artificial Intelligence and Robotics)/ Artificial Intelligence (AI) and Data Science/ Artificial Intelligence (AI) and Machine Learning]

(Batch admitted in academic session 2023 – 24)

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SOFTWARE ENGINEERING (3240521)

COURSE OBJECTIVES

- To understand the process of software development and software life cycle models.
- To understand project management and risk management associated with various types of projects.
- To know the familarize with the concept of software testing, quality assurance and configuration management process.

Unit - I

Introduction to Software Engineering: Definition, Software Engineering-Layered Technology, Software Characteristics and Components, Software Model: Software Development of Life Cycle Model (SDLC), The Waterfall Model, Iterative Waterfall Model, Prototyping Model, Spiral Model, RAD Model. Selection Criteria of Model: Characteristics of Requirements, Status of Development Team, Users Participation, Type of Project and Associated Risk.

Unit - II

Requirement Engineering: Definition, Requirement Engineering Activity , Types of Requirement- Functional and Nonfunctional Requirements, User and System Requirements, Requirement Elicitation Methods, Requirement Analysis Methods, Requirement Documentation (SRS), Requirement Validation, Requirement Management.

Unit - III

Design Concept, Principle and Methods: Design Fundamentals, Design Principles, Effective Modular Design, Design Representations, Architectural Design, Procedural Design, Data Directed design, Real Time Design, Object Oriented Design, Coupling and Cohesion.

Unit - IV

Software Metrics, Project Management and Estimation: Metrics in Process and Project Domains, Software Measurement, Software Quality Metrics, Project Management-Basics-People, Product, Process, Project, Estimation- Software Project Estimation, Decomposition Techniques- Function Point Estimation, Line of Code (LOC) Based estimation, Empirical Estimation, COCOMO Model, Project Scheduling Techniques.

Unit - V

Software Testing: Definitions, Software Testing Life Cycle (STLC), Test Case Design, Strategic Approach to Software Testing- Verification & Validation , Strategic Issues, Criteria for Completion of Testing, Unit Testing, Integration Testing, Validation Testing, System Testing, Black Box Testing Techniques, White Box Testing Techniques, Acceptance Testing.

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RECOMMENDED BOOKS

1. Software Engineering, Sommerville, Pearson.
2. Software Engineering: A Practitioner’s Approach, Roger S. Pressman, McGraw Hill.
3. Software Engineering, K.K. Agrawal & Yogesh Singh, New Age Publication.
4. Software Engineering, Rajib Mall, PHI.

COURSE OUTCOMES

After completion of this course, the students would be able to:

CO1. explain the concepts of software engineering.

CO2. analyze and design software for real world problems.

CO3. compare the techniques for software project management & estimation.

CO4. choose an appropriate software development model for a real-life software project.

CO5. design software using modern tools and technologies.

CO6. test the software through different approaches.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	1	1	2	1	2	1		3	2	1
CO2	3	3	3	3	3	2	3	2	2	1	2	3	3	1
CO3	3	3	3	3	3	2	2	1	1	1	1	3	1	2
CO4	3	3	3	3	3	3	3	1	3	2	2	2	2	2
CO5	3	3	3	3	3	3	3	3	2	2	3	3	2	2
CO6	3	3	3	3	3	3	3	3	3	2	3	3	2	2

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DATA MINING & WAREHOUSING (3270521/ 3280521)

COURSE OBJECTIVES

- To understand the significance of data mining in a real-world perspective. and gain the understanding of data mining techniques, algorithms and commonly used tools.
- To develop the ability for applying data mining techniques and tools for solving real-world problems.

Unit I

Introduction: Motivation, importance, Data types for Data Mining: Relational Databases, Data Ware-Houses. Transactional Databases, Advanced Database System and Its Applications, Data Mining Functionalities, Concept/Class Description, Association Analysis Classification & Prediction, Cluster Analysis, Outliner Analysis, Classification of Data Mining Systems, Major Issues in Data Mining.

Unit II

Data Pre-processing: Data Cleaning, Data Integration and Transformation and Data Reduction. Discretization and Concept Hierarchy Generation. Data Mining Primitives Languages and System Architectures, Concept Description, Characterization and Comparison Analytical, Characterization. Data Warehouse and OLTP Technology for Data Mining: Differences between Operational Database Systems & Data Warehouse, Multidimensional Data Model, Data Warehouse Architecture, Data Warehouse Implementation, Data Cube Technology

Unit III

Mining Association Rules in Large Databases: Association Rule Mining: Market Basket Analysis, Basic Concepts, Mining Single Dimensional Boolean Association Rules from Transactional Databases: The Apriori Algorithm, Generating Association Rules from Frequent Items, Improving the Efficiency of Apriori, other Algorithms & their Comparison, Mining Multilevel Association Rules, Multidimensional Association Rules, Constraint Based Association Rule Mining.

Unit IV

Classification & Prediction and Cluster Analysis: Issues Regarding Classification & Prediction, Different Classification Methods, Prediction, Cluster Analysis, Major Clustering Methods, Currently Available Tools.

Unit V

Introduction to data warehousing, need and significance, challenges & issues in warehousing, difference between data mining & warehousing, case studies- stock market, super market etc. , implementation of current applications involving data mining.

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RECOMMENDED BOOKS

1. Data Mining: Concepts and Techniques, Han and Kamber, Morgan Kaufmann Publications.
2. Data Mining Techniques, A. K. Pujari, Universities Press Pvt. Ltd.
3. Data Warehousing in the Real World, Sam Anahory, Pearson Publication.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1: explain fundamental concepts of data mining and data warehousing.

CO2: classify database systems and data models of data warehouses.

CO3: compare methods for storing & retrieving data from different data sources.

CO4: apply data mining techniques for knowledge extraction from large amounts of data.

CO5: predict trends to make informed decisions.

CO6: develop real world applications using data mining techniques.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	2	1	1	1	1	3	1	1
CO2	3	3	3	3	3	3	2	1	1	2	1	3	2	2
CO3	3	3	3	3	3	3	2	2	2	1	2	3	2	2
CO4	3	3	3	3	3	3	3	3	3	2	3	3	3	3
CO5	3	3	3	3	3	3	3	2	2	2	2	3	3	3
CO6	3	3	3	3	3	3	3	3	3	2	3	3	3	3

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DATA SCIENCE (3240522/ 3270522/ 3280522)

COURSE OBJECTIVES

- To provide fundamental knowledge about Data Science
- To understand data preprocessing techniques
- To analyze the Data Science techniques solutions for real world problems

Unit I

Understanding Data: Types of Data, Source, Data Science Life Cycle, Data Collection Techniques. Ethical Considerations: Privacy and Consent; Data Ownership and Rights; Bias and Fairness in Data Collection. Data Cleaning; Handling missing values, Outlier detection and treatment, Data deduplication.

Unit II

Data Transformation: Normalization and standardization, Encoding categorical variables (one-hot encoding, label encoding), Feature scaling, Feature Engineering:Feature extraction, Time-based features, Data Integration:Merging data from multiple sources, Resolving schema conflicts, Data Reduction:Feature Selection; Filter methods, Wrapper methods PCA and LDA.

Unit III

Descriptive Statistics and Inferential statistics: Analyzing and Summarizing Data, Measures of Central Tendency: Mean, Median, and Mode, Measures of Dispersion: Variance, Standard Deviation, and Range. Variability in Data, Graphical Representations: Histograms; Visualizing Data Distribution Box plots; Identifying Outliers and Quartiles. Scatter plots; Examining Relationships between Variables, Hypothesis Testing (z-test, t-test, chi-squared test).

Unit IV

Supervised Learning: Regression: Linear regression, polynomial regression. Performance metrics for regression: R, R-Square, Mean Square Error(MSE), Root Mean Square Error (RMSE) Classification: Binary and Multi class classification, Logistic regression, Decision tree, Performance metrics for classification: Accuracy; Sensitivity; Specificity; Area Under the Curve (AUC); Recursive Operating Characteristic (ROC); Error Matrix; Type-I and Type II Error; F-Measures. Cross Validation, Bias-Variance Tradeoff, Validation on Benchmark Dataset, Hyperparameter Tuning.

Unit V

Unsupervised Learning: Clustering, K-means, Hierarchical clustering, Anomaly Detection, Density Estimation, Evaluation Metrics: Silhouette score; Davies-Bouldin index; Adjusted Rand Index (ARI).

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RECOMMENDED BOOKS

1. "The Data Science Handbook" by Field Cady, Publisher: Wiley
2. "Data Science from Scratch" by Joel Grus, Publisher: O'Reilly
3. “An Introduction to Statistical Learning: With Applications in R” by Gareth M. James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Publisher: Springer
4. “An Introduction to Statistical Learning: With Applications in R” by Gareth M. James, Daniela Witten, Trevor Hastie, Robert Tibshirani, Publisher: Springer

COURSE OUTCOMES

After completion of the course students will be able to:

CO1 define the concepts and importance of data science.
CO2 describe and investigate the data.
CO3 implement descriptive and inferential statistics approach on real world data
CO4 develop real world solutions using supervised and unsupervised learning methods.
CO5 evaluate the best performing algorithms based on performance metrics.
CO6 examine the stability of machine learning based models.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3			2		2	1		3	2	1
CO2	3	3	3	3	1	2		2					3	1
CO3	3	3	3	3			1				1		1	2
CO4	3	3	3	3		1		1	3	2	2	2	2	2
CO5	3	3	3	3	2	2			2				2	2
CO6	3	3	3	3	2		2	2		2	2	3	2	2

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DATA SCIENCE (3240522/ 3270522/ 3280522)

List of Experiment

1. Write a program to Normalize and standardize the data.
2. Write a program to Investigate bias in a dataset.
3. Write a program to explore a dataset using descriptive statistics.
4. Write a program to Create visualizations (box plots, scatter plots) to identify outliers and relationships between variables.
5. Build a linear regression model to predict a continuous target variable (e.g., house prices based on features like area and location).
6. Evaluate model performance using R-squared, MSE, and RMSE.
7. Implement logistic regression for binary classification.
8. Evaluate accuracy, sensitivity, and specificity.
9. Construct a decision tree for multi-class classification.
10. Visualize the decision tree and assess its performance.

Course Outcomes:
After completion of the course, students will be able to
CO1. define the concepts and importance of data science.
CO2. describe and investigate the data.
CO3. implement descriptive and inferential statistics approach on real world data
CO4. develop real world solutions using supervised and unsupervised learning methods.
CO5. evaluate the best performing algorithms based on performance metrics.
CO6. examine the stability of machine learning based models.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3			2		2	1		3	2	
CO2	3	3	3	3	1	2		2					3	1
CO3	3	3	3	3			1				1			2
CO4	3	3	3	3		1		1	3	2	2	2	2	
CO5	3	3	3	3	2	2			2					
CO6	3	3	3	3	2		2	2		2	2	3	2	2

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DATA SCIENCE (3240522/ 3270522/ 3280522)

Skill based Mini Projects

Micro Projects:

1. Analyze customer data and segment them into meaningful groups. You can use clustering algorithms like K-means or DBSCAN.
2. Create a basic movie recommendation system.
3. Build a deep learning model to classify breast cancer as malignant or benign.

Macro Projects:

1. Develop a machine learning model to detect fraudulent credit card transactions. Explore anomaly detection techniques and evaluate model performance.
2. Build a model to detect fake news articles.
3. Use machine learning algorithms to identify fraudulent credit card transactions. Explore techniques like anomaly detection and classification

Mini Projects:

1. Use historical stock price data to predict future stock prices. Explore time series analysis and machine learning algorithms.
2. Combine computer vision and natural language processing to generate captions for images. You'll need a deep learning model like a convolutional neural network (CNN) and a recurrent neural network (RNN).
3. Create a system that detects driver fatigue based on facial expressions or eye movements. Use computer vision techniques and machine learning.
4. Analyze sentiments in text data.

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THEORY OF COMPUTATION (3240523)

COURSE OBJECTIVES

- To understand computability, decidability, and complexity through problem solving.
- To analyze and design abstract model of computation & formal languages
- To understand and conduct mathematical proofs for computation and algorithms.

Unit I

Introduction of Automata Theory: Examples of automata machines, Finite Automata as a language acceptor and translator, Moore machines and mealy machines, composite machine, Conversion from Mealy to Moore and vice versa.

Unit II

Types of Finite Automata: Non Deterministic Finite Automata (NDFA), Deterministic finite automata machines, conversion of NDFA to DFA, minimization of automata machines, regular expression, Arden's theorem. Meaning of union, intersection, concatenation and closure, 2 way DFA.

Unit III

Grammars: Types of grammar, context sensitive grammar, and context free grammar, regular grammar. Derivation trees, ambiguity in grammar, simplification of context free grammar, conversion of grammar to automata machine and vice versa, Chomsky hierarchy of grammar, killing null and unit productions. Chomsky normal form and Greibach normal form.

Unit IV

Push down Automata: example of PDA, deterministic and non-deterministic PDA, conversion of PDA into context free grammar and vice versa, CFG equivalent to PDA, Petri Net model.

Unit V

Turing Machine: Techniques for construction. Universal Turing machine Multitape, multihead and multidimensional Turing machine, N-P complete problems. Decidability and Recursively Enumerable Languages, decidability, decidable languages, undecidable languages, Halting problem of Turing machine & the post correspondence problem.

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RECOMMENDED BOOKS

1. Introduction to Automata Theory Language & Computation, Hopcroft & Ullman, Narosa Publication.
2. Element of the Theory Computation, Lewis & Christors, Pearson.
3. Theory of Computation, Chandrasekhar & Mishra, PHI.
4. Theory of Computation, Wood, Harper & Row.
5. Introduction to Computing Theory, Daniel I-A Cohen, Wiley.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1 explain the basic concepts of switching and finite automata theory & languages.
CO2 relate practical problems to languages, automata, computability and complexity.
CO3 construct abstract models of computing and check their power to recognize the languages.
CO4 analyze the grammar, its types, simplification and normal form.
CO5 interpret rigorously formal mathematical methods to prove properties of languages, grammars and automata.
CO6 develop an overview of how automata theory, languages and computation are applicable in engineering applications.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	3	2	2	2			2	2	3	1	1
CO2	2	3	3	2	3	3	3	2		3	3	3	2	2
CO3	3	3	3	3	3	3	3		2	2	2	2	2	2
CO4	3	2	3	3	2	3	3		3	3	2	3	3	2
CO5	3	2	2	3	3	3	2	2		2	3	3	3	3
CO6	3	2	2	3	2	2	2	2				2	2	2

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COMPILER DESIGN (3270523/ 3280523)

COURSE OBJECTIVES

- Introduce the structure and phases of a compiler.
- Familiarize students with lexical, syntactic, and semantic analysis.
- Enable the design and implementation of parsers and code generators.

Unit I

Introduction to Compilers: Overview of Compilation: Compiler vs Interpreter, Phases of a Compiler: Lexical, Syntax, Semantic, Intermediate Code Generation, Optimization, Code Generation, Code Linking, Compiler construction tools: Lex, Yacc, and equivalents, Bootstrapping and Cross Compilation.

Unit II

Lexical Analysis: Role of Lexical Analyzer, Input Buffering, Specification of Tokens, Regular Expressions and Finite Automata (DFA, NFA), Construction of Lexical Analyzer using Lex or Flex.

Unit III

Syntax Analysis: Context-Free Grammars, Parse Trees and Derivations, Top-down Parsing: Recursive Descent, LL(1), Bottom-up Parsing: Operator Precedence, LR, SLR, LALR, Syntax Error Handling.

Unit IV

Semantic Analysis and Intermediate Code Generation: Syntax-directed Definitions and Translation Schemes, Symbol Tables and Scoping, Type Checking and Type Conversion, Intermediate Code Generation: Three Address Code, Quadruples, Triples, Backpatching and Boolean Expression Handling.

Unit V

Code Optimization and Code Generation: Issues in Code Generation, Basic Blocks and Control Flow Graphs, Peephole Optimization, Loop Optimization, DAG Representation, Code Generation Algorithms, Register Allocation and Instruction Scheduling.

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RECOMMENDED BOOKS

1. Alfred V. Aho, Monica S. Lam, Ravi Sethi, Jeffrey D. Ullman, Compilers: Principles, Techniques and Tools, 2nd Edition, Pearson Education (Dragon Book).
2. Dick Grune et al., Modern Compiler Design, Springer.
3. Keith D. Cooper and Linda Torczon, Engineering a Compiler, Morgan Kaufmann.
4. Andrew W. Appel, Modern Compiler Implementation in C/Java/ML, Cambridge University Press.
5. Allen I. Holub, Compiler Design in C, Prentice Hall.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1	Explain the phases and architecture of a compiler and its components.
CO2	Construct lexical analyzers and parsers using formal grammars and automated tools.
CO3	Analyze syntactic and semantic structures using context-free grammars and syntax trees.
CO4	Evaluate and optimize intermediate code representations for efficient target code generation.
CO5	Design and implement a simple compiler for a miniature programming language.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	1	1				1			1	1	1
CO2	3	3	3	1	2	1	1		1	2	1	2	1	1
CO3	3	3	3	3	2	1	1	1	1	2	1	2	1	1
CO4	3	3	3	3	2	1	1	1	1	3	1	2	2	2
CO5	3	3	3	3	2	2	1	1	1	3	2	2	2	2

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ROBOT OPERATING SYSTEM (3240524)

COURSE OBJECTIVES

- To study Robot programming fundamentals and ROS platform
- To understand the installation and applications of ROS
- To understand the Robot navigation through Simulations.

Unit I

Introduction to Robotics: Laws of Robotics, Different types of robots, Applications of Robotics, Review of sensors control actions and actuators, Robot kinematics and dynamics, Trajectory planning approaches.

Unit II

Learning Basics of Ubuntu/Linux: Linux basic commands for robotics, Linux IDE & Text Editor: VS Code, nano, gedit, Linux and I/O board communication: USB to Serial communication, Linux and Camera interfacing, Linux kernel customization, Raspberry Pi and Linux overview, Linux commands, GPIO handling.

Unit III

Learning Basics of Robot Simulator: Getting started with Robot simulator concepts, Overview of different robotic simulators: Webots, Ignition, Gazebo & CoppeliaSim, Robot Programming: Getting started with ROS, ROS Equation, Utility and applications of ROS

Unit IV

ROS Architecture and concepts, Various file systems of ROS, ROS Coding styles, IDE, ROS Hello World, ROS TurtleSim, ROS Workspace and package, ROS Client libraries: roscpp & rospy, Understanding roslaunch, rosbag, Rviz, rqt. Applications of ROS in Robotics.

Unit V

Learning ROS programming using TurtleSim: roscpp and rospy, Understanding ROS concepts using TurtleSim, Moving TurtleSim using ROS programming, Understanding Transformation and frames, Working with TF broadcaster and listener, Creating TF for your robot, Working with ROS TF tools, TurtleSim projects, draw your caricature using TurtleSim, Object tracking using TurtleSim.

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RECOMMENDED BOOKS

1. Robot Operating System for Absolute Beginners: Robotics Programming Made Easy“
2. Programming Robots with ROS” by Quigley, Gerkey and Smart.
3. The Linux Command Line” by William Shotts.
4. “It-Yourself Guide to the Robot Operating System: Volumes” by Patrick Goebel.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1 demonstrate knowledge of operating system dedicated to Robot
CO2 analyze various case studies of ROS application
CO3 apply spatial transformation to obtain forward and inverse kinematics through programming
CO4 solve robot dynamics problems, generate joint trajectory for path planning and Programming
CO5 apply working principle of various ROS debugging process
CO6 identify applications of robots in industry

CO-PO Mapping Matrix														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	3	3	3	2			2		2	1		3	2	
CO2	3	3	3	1	1	2		2					3	1
CO3	3	3	3	3			1				1			2
CO4	3	3	3	3		1		1	3		2	2		
CO5	3	3	3	3	2	2			2					
CO6	3	2	3	3			2	2		2	2	3	2	2

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ROBOT OPERATING SYSTEM (3240524)

1. Implement basic Linux commands for terminal operations in ROS environment
2. Implement virtual machine concepts and Installation of ROS environment.
3. Creation of basic inter nodes communication between Talker listener nodes.
4. Create ROS2 nodes using the Turtlesim simulator of the ROS environment.
5. Executing Turtlesim for running nodes, teleoperations, swamping and remapping of nodes.
6. Implementation of Mitsubishi Robotic Arm, calibration and Melfa programming basics.
7. Perform object Pick and Drop operations through Mitsubishi robotic arm.
8. Perform various operations on Smorphy robotic kit and implement its remote navigation process.
9. Design a voice based action synchronization for a humanoid Robot.

COURSE OUTCOMES

After completing this, the students will be able to:

CO1. illustrate the basics of Robot operating system simulation interface.

CO2. explain basic Linux commands for ROS installation.

CO3. demonstrate node concepts in multi-Robot system communication.

CO4. apply basic robotic actions with Robotic arm

CO5. analyze the robotic prototypes used in various industries

CO6. demonstrate various actions using humanoid robots.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3			2		2	1		3	2	
CO2	3	3	3	3	1	2		2					3	1
CO3	3	3	3	3			1				1			2
CO4	3	3	3	3		1		1	3		2	2		
CO5	3	3	3	3	2	2			2					
CO6	3	3	3	3			2	2		2	2	3		

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ROBOT OPERATING SYSTEM (3240524)

Skill based Mini Projects

Micro Project:

- Study of Raspberry pi board
- Understanding the line follower system.
- Create an electronic obstacle avoidance system.
- Implement a SLAM model.
- Implement GaZebo in ROS
- Perform kinematics for Robotics arm
- Design a Gesture control flow in Robotic Applications
- Implement various functions of Drones.

Macro Projects:

- Perform operations with Raspberry pi board sensor interfacing units
- Implement different sensors used in line follower.
- Design a SLAM and Turtle sim node navigation system
- Implement path planning with Turtle sim node system
- Perform various functions pertaining to drone kinematics
- Design a joint coordinate system for Robotic Arm
- Implement a Lidar sensor in robot Navigation.
- Perform Humanoid Calibration.

Mini Project:

- Design of Line Following Robot using ROS with Raspberry Pi.
- Design of obstacle avoidance Robot using ROS with Raspberry Pi.
- Implementation of SLAM using ROS TurtleSim.
- Path Planning robot using Raspberry and ROS.
- Drone simulation using Gazebo and ROS
- Robotic Arm simulation using ROS
- Gesture controlled robot using ROS
- Design an Autonomous mobile robot using ROS

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STATISTICAL PROGRAMMING WITH R (3270524/ 3280524)

COURSE OBJECTIVES

- To understand the principles of traditional and computational statistics
- To develop proficiency in R programming, and apply computational statistics techniques

Unit I

Introduction to R: R Commands, Objects, Functions, Simple Manipulations, Matrices and Arrays, Factors, Lists, Data Frames. Introduction to Statistics: Traditional vs. Computational Statistics, Data Import and Manipulation in R, Exploratory Data Analysis (EDA).

Unit II

Scripts, Logical Operators, Conditional Statements, Loops in R, Switch Statement, Creating List and Data Frames, List and Dataframe Operations, Recursive List, Function Creation in R, Statistical Functions in R.

Unit III

Data Visualization in R, Implementing Statistical Functions in R, Implementing algorithms for estimation and hypothesis testing, Utilizing R packages for specialized statistical techniques.

Unit IV

Estimation Techniques, Implementing estimation techniques in Parameter Estimation in Practice, Application of estimation techniques to real-world datasets, Interpretation of estimated parameters within the context of the problem domain, Strategies for model selection and validation in computational statistics.

Unit V

Introduction to Randomization Techniques, Random sampling and random assignment principles, Bootstrapping and permutation tests as randomization techniques, Implementing Randomization Techniques in R, Randomization in Large Datasets, Efficient algorithms for random sampling and permutation in R.

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RECOMMENDED BOOKS

1. Givens, G. H. and Hoeting, J. A. (2013). Computational Statistics (2nd ed.). Hoboken, NJ: John Wiley & Sons, Inc.
2. Gentle, J. E. (2009). Computational Statistics. New York, NY: Springer.
3. An Introduction to Statistical Learning: with Applications in R (Springer Texts in Statistics) by Gareth James (Author), Daniela Witten (Author), Trevor Hastie (Author), Robert Tibshirani (Author)
4. Wendy L. Martinez and Angel R, "Martinez Computational Statistics," Chapman & Hall/CRC, 2002.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1	Compare and contrast traditional and computational statistics, explaining the role of computation as a tool of discovery
CO2	Implement computational statistics techniques using the software R.
CO3	Estimate statistical functions or parameters by selecting and implementing appropriate computational statistics techniques
CO4	Evaluate the choice of applying a specific computational statistics technique to a given problem.
CO5	Apply randomization techniques to extract information from large data sets.
CO6	Generate graphical displays as a tool for analyzing both large data sets and computational statistics techniques.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	3	2	1	2	3	3	2	3	3	2
CO2	3	3	3	3	3	3	2	1	2	3	3	2	3	3
CO3	3	3	3	3	3	2	1	2	3	3	2	3	3	3
CO4	3	3	3	2	2	1	2		3	2	2	3	2	3
CO5	3	2	2	3	3	1	2		2	3	2	2	2	2
CO6	3	3	3	3	3	3	2		2	2		2	3	3

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STATISTICAL PROGRAMMING WITH R (3270524/ 3280524)

List of Programs

1. Installation of R and R studio
2. Use R to explore datasets visually and numerically using histograms, box plots, scatter plots, and summary statistics.
3. Implement vectors, matrices, sorting and indexing in R
4. Implement conditional expressions, vectorization and functions in R
5. Summarize and sort data with R
6. Implement probability and monte carlo simulations in R
7. Implement Central limit theorems in R
8. Create populations, samples, parameters and estimates using R
9. Implement Bayesian Statistics and regression in R
10. Implement various methods of data wrangling.

Skill based Mini Projects

1. Choose a dataset from a repository like Kaggle and perform comprehensive EDA using R. Generate visualizations such as histograms, box plots, scatter plots, and compute summary statistics.
2. Choose a real-world dataset and create an R script to summarize and sort the data based on various attributes. Implement functions to calculate different summary statistics for the dataset.3.
3. Select a messy or incomplete dataset and clean it using R. Tasks may include handling missing values, correcting data types, removing duplicates, and standardizing formats.
4. Obtain a time series dataset from sources like financial markets, weather stations, or social media. Use R to analyze trends, seasonality, and correlations within the time series data.
5. Choose a dataset suitable for predictive modeling tasks, such as predicting house prices, customer churn, or disease diagnosis. Split the dataset into training and testing sets, and build predictive models using techniques like linear regression, decision trees, or random forests. Evaluate model performance using metrics like accuracy, precision, recall, and ROC curves.
6. Obtain a spatial dataset containing geographic information, such as maps, satellite imagery, or GPS data. Use R packages like sp and rgdal to perform spatial analysis tasks such as point pattern analysis, spatial autocorrelation, or interpolation.
7. Choose a population dataset and simulate the process of drawing multiple samples from it in R. Calculate sample statistics and compare them with population parameters to understand the concept of estimation.
8. Implement Bayesian linear regression in R using packages like rstan or brms. Apply the model to a dataset and interpret the results, including posterior distributions and credible intervals.

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SOFT COMPUTING TECHNIQUES (3240525)

COURSE OBJECTIVES

- To provide the student with the basic understanding of neural networks and fuzzy logic fundamentals, Program the related algorithms and Design the required and related systems.
- To understand the fundamental theory and concepts of neural networks, several neural network paradigms and its applications.
- To understand the basics of an evolutionary computing paradigm known as genetic algorithms and its application to engineering optimization problems.

Unit I

Introduction to Soft Computing: Soft Computing v/s Hard Computing, Basic models of Artificial Neural Networks, Terminologies of ANNs McCulloch-Pitts Neurons, Linear Separability, Hebb Network, Supervised Learning Networks: Introduction, Perceptron Networks, Back Propagation Networks, Radial Basis Function Networks, Hopfield networks.

Unit II

Fuzzy Set Theory: Fuzzy Sets, Fuzzy Membership Functions, Operations on Fuzzy Sets, Fuzzy Relations, Fuzzy rules, Fuzzy Reasoning, Defuzzification: Lambda-Cuts for Fuzzy sets (Alpha-Cuts), Lambda-Cuts for Fuzzy Relations. Fuzzy Inference System: Introduction, Mamdani Fuzzy Model, Takagi-Sugeno Fuzzy Model.

Unit III

Evolutionary Algorithm: Traditional optimization and Search Techniques, Basic Terminologies in GA, Operators in Genetic Algorithm, Stopping Condition for Genetic Algorithm Flow, Classification of Genetic Algorithm, Comparison with Evolutionary algorithm, Application of Genetic algorithm.

Unit IV

Introduction to Nature-Inspired Optimization Algorithms: Particle Swarm Optimization (PSO) Algorithm, Differential Evolution (DE) Algorithm, Artificial Bee Colony (ABC) Algorithm, Ant Colony Optimization (ACO) Algorithm, Cuckoo Search (CS), Firefly Algorithm (FA), Immune Algorithm (IA), Grey Wolf Optimization (GWO), Spider Monkey Optimization.

Unit V

Hybrid Soft Computing Techniques: Introduction, Neuro-fuzzy Hybrid system, Adaptive Neuro fuzzy inference system(ANFIS), Genetic Neuro Hybrid system, Application of Soft Computing Techniques.

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RECOMMENDED BOOKS

1. Principles of Soft Computing, S. N. Sivanandam and S. N. Deepa , Wiley Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications- S. Rajasekaran & G.A. Vijayalakshmi Pai, PHI.
2. Introduction to Soft Computing Neuro-Fuzzy and Genetic Algorithms, Samir Roy and Udit Chakraborty, Pearson.
3. Neural Networks and Learning Machines-Simon Haykin PHI.
4. Fuzzy Logic and Engineering Application, Tomthy Ross, TMH.
5. Evolutionary Optimization Algorithms, D. Simon (2013), Wiley.
6. Fundamentals of Natural Computing: Basic Concepts, Algorithms, and Applications, L. N. de Castro (2006), CRC Press.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1 define basic concepts of neural networks and fuzzy systems.
CO2 compare solutions by applying various soft computing approaches on a given problem.
CO3 develop and train different supervised and unsupervised learning.
CO4 classify various nature inspired algorithms according to their application aspect.
CO5 compare the efficiency of various hybrid systems.
CO6 design a soft computing model for solving real world problems.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3								2	2	2
CO2	3	3	3	3	2	2			1			2	3	3
CO3	3	3	3	3	3	3						1	3	3
CO4	3	3	3	3			2		1	1		1	3	3
CO5	3	3	3	3									1	1
CO6	3	3	3	3	3	2			1	1		1	3	3

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MACHINE LEARNING & OPTIMIZATION (3270525/ 3280525)

COURSE OBJECTIVES

- To understand the foundational concepts of machine learning and mathematical optimization.
- To apply supervised, unsupervised, and reinforcement learning algorithms to real-world problems.
- To analyze model performance and fine-tune hyperparameters for optimization.

Unit I

Introduction to Machine Learning: Types of Machine Learning: Supervised, Unsupervised, Reinforcement Learning, Applications and challenges, Key Concepts: Model, Training, Testing, Features, Labels, Evaluation Metrics: Accuracy, Precision, Recall, F1 Score, ROC-AUC.

Unit II

Supervised Learning and Optimization: Linear Regression, Logistic Regression, Support Vector Machines (SVM), Decision Trees, Random Forests, Gradient Descent and Variants (SGD, Mini-batch GD, Momentum, Adam), Overfitting, Underfitting, Regularization (L1, L2).

Unit III

Unsupervised Learning: Clustering: K-means, Hierarchical, DBSCAN, Dimensionality Reduction: PCA, t-SNE, Anomaly Detection, Applications in image and text data.

Unit IV

Optimization Techniques: Convex vs. Non-convex Optimization, Constrained and Unconstrained Optimization, Evolutionary Algorithms (Genetic Algorithm, Particle Swarm Optimization), Simulated Annealing, Bayesian Optimization, Multi-objective Optimization.

Unit V

Advanced Topics and Applications: Neural Networks and Deep Learning basics, Reinforcement Learning and Policy Optimization, Hyperparameter Tuning (Grid Search, Random Search, Bayesian Optimization), Case Studies: ML in Healthcare, Finance, IoT, Ethical Considerations and Bias in ML.

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RECOMMENDED BOOKS

1. Tom M. Mitchell, Machine Learning, McGraw-Hill, 1997.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Springer.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. Kevin P. Murphy, Machine Learning: A Probabilistic Perspective, MIT Press.
5. S. S. Rao, Engineering Optimization: Theory and Practice, Wiley.

COURSE OUTCOMES

After completion of the course students will be able to:

CO1 Explain the basic principles of machine learning and different categories of learning algorithms.

CO2 Apply supervised and unsupervised machine learning models to solve engineering and data-centric problems.

CO3 Evaluate model performance and analyze the effect of various hyperparameters and regularization techniques.

CO4 Design and implement optimized machine learning workflows using relevant tools and libraries.

CO5 Assess the optimization techniques applied in model training and selection for real-world scenarios.

CO-PO Mapping Matrix

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	3	2	2	1		1	1	2	1	1	1
CO2	3	3	3	3	3	2	1	2	1	3	2	2	3	3
CO3	3	3	3	3	3	2	1	2	1	3	2	3	3	3
CO4	3	3	3	3	3	3	2	2	1	3	2	3	3	3
CO5	3	3	3	3	3	3	3	2	1	3	3	3	3	3