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(Accredited by NAAC with Grade A+)

GU/Acad –PG/BoS -NEP/2026-27/122 Date: 04.06.2026

CIRCULAR

Ref. No.: GU/Acad –PG/BoS -NEP/2026/830 dated 13.03.2026

In supersession to the above referred Circular, the syllabus of Semester III and IV of the **Master of Science in Data Science** Programme approved by the Standing Committee of the Academic Council in its meeting held 24th & 25th November 2025, is attached.

Further, the Syllabus of Semester I and II approved earlier by the Academic Council in its meeting held on 13th & 14th June 2025 is also attached.

The Dean & Vice-Dean (Academic) of the Goa Business School is requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

ASHWIN V LAWANDE Digitally signed by ASHWIN V LAWANDE Date: 2026.06.04 15:10:50 +05'30'

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, Goa Business School, Goa University.
2. The Vice-Dean (Academic), Goa Business School, Goa University.

Copy to:

3. Chairperson, BoS in Data Science and Artificial Intelligence, Goa University.
4. Programme Director, M.Sc. Data Science, Goa University.
5. Controller of Examinations, Goa University.
6. Assistant Registrar Examinations (PG), Goa University.
7. Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENC IN DATA SCIENCE

(Effective from the Academic Year 2025-2026)

ABOUT THE PROGRAMME

The M.Sc. Data Science programme is a two-year postgraduate programme designed for undergraduates in Computer Science, IT, Data Science, Artificial Intelligence, related Science disciplines, and Engineering streams. It provides a strong foundation in statistics, mathematics, and computer science, equipping students with practical skills in data analysis, machine learning, big data technologies, and data-driven decision-making.

The programme emphasizes interdisciplinary learning, hands-on experience with modern tools, and the development of critical thinking, ethical awareness, and analytical reasoning. Graduates will be prepared for careers in industry, research, or academia, with the capacity to drive innovation, entrepreneurship, and research-led solutions in the data science domain.

OBJECTIVES OF THE PROGRAMME

1. To provide a strong understanding of core concepts in statistics, mathematics, and computer science that serve as a foundation for data science practices.
2. To train students with practical skills in using modern tools, programming environments, and big data technologies for the end-to-end lifecycle of data, from collection and processing to analysis, interpretation, and visualization in real-world applications.
3. To cultivate critical thinking and analytical reasoning necessary for designing data-driven solutions to diverse real-world challenges.
4. To promote a research-oriented mindset through systematic problem formulation, experimental design, and analytical evaluation.

PROGRAMME SPECIFIC OUTCOMES (PSO)	
PSO 1.	Demonstrate fundamental knowledge of statistics, mathematics, and computer science concepts essential for data science.
PSO 2.	Apply data analysis tools and software to manage, process, and analyze data.
PSO 3.	Cultivate critical thinking and analytical reasoning skills to design data science-enabled solutions.
PSO 4.	Develop proficiency in implementing machine learning algorithms and models to address real-world challenges across diverse domains.
PSO 5.	Develop expertise in visualizing complex datasets and effectively communicating data-driven insights.
PSO 6.	Foster a research-oriented mindset, enabling the formulation of research problems, experimentation, and analysis to address emerging research challenges in data science.
PSO 7.	Apply ethical principles, ensuring their data science practices respect privacy and align with societal values and legal standards.
PSO 8.	Apply data science expertise to contribute to addressing societal issues

PROGRAMME STRUCTURE

Master of Science in Data Science

Effective from Academic Year 2025-26

SEMESTER I				
Discipline Specific Core (DSC) Courses (16 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSD-5000**	Principles of Data Science	4T	400
2	**CSD-5001**	Mathematical Foundations for Data Science	4T	400
3	**CSD-5002**	Problem Solving and Programming Fundamentals	2T	400
4	**CSD-5003**	Data Science Lab	3P	400
5	**CSD-5004**	Mathematical Foundations for Data Science Lab	3P	400
Total Credits for DSC Courses in Semester I			**16**	
Discipline Specific Elective (DSE) Course (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSD-5201**	Data Management	4T	400
2	**CSD-5202**	Algorithms and Computational Complexity	4T	400
Total Credits for DSE Courses in Semester I			**4**	
Total Credits in Semester I			**20**	

SEMESTER II				
Discipline Specific Core (DSC) Courses				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-5005	Machine Learning Techniques	3T	500
2	CSD-5006	Data Modeling and Visualization	2T	500
3	CSD-5007	Internet of Things	2T	500
4	CSD-5008	Optimization Techniques	3T	500
5	CSD-5009	Machine Learning Techniques Lab	2P	500
6	CSD-5010	Data Modeling and Visualization Lab	2P	500
7	CSD-5011	Internet of Things Lab	2P	500
Total Credits for DSC Courses in Semester II			**16**	
Discipline Specific Elective (DSE) Courses (4 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-5203	Domain-Specific Predictive Analytics	4T	400
2	CSD-5204	Data Security, Privacy and Ethics	4T	400
Total Credits for DSE Courses in Semester II			**4**	
Total Credits in Semester II			**20**	

SEMESTER III				
Research Specific Elective (RSE) Courses (12 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-6000	Research Methodology	4T	500
2	CSD-6001	Reinforcement Learning Techniques	4T	500
3	CSD-6002	Deep Learning Models	4T	500
4	CSD-6003	Regression Analysis and Predictive Model	4T	500
5	CSD-6004	Data Engineering	4T	500
6	CSD-6005	Artificial Intelligence	4T	500
7	CSD-6006	Natural Language Processing	4T	500
8	CSD-6007	Applied Data Science in Agriculture	4T	500
9	CSD-6008	Recommender System	4T	500
10	CSD-6009	Sentiment Analysis	4T	500
		Total Credits for RSE Courses in Semester III	**12**	
Discipline Specific Vocational Elective (DSVE) Courses (8 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-6401	Software Engineering for Data-Driven Applications	2T+2P	500
2	CSD-6402	Machine Learning Operations (MLOps)	2T+2P	500
3	CSD-6403	Cloud-Based Big Data Solutions	2T+2P	500
4	CSD-6404	Building Data-Driven Web and Mobile Applications	2T+2P	500
		Total Credits for DSVE Courses in Semester III	**8**	
		Total Credits in Semester III	**20**	

Discipline Specific Dissertation (DSD) (40 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-6501	Dissertation	**40**	**500**

SEMESTER IV				
Generic Elective (GE) Courses (20 credits)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	CSD-6201	Design Thinking for Data Intensive Applications	4T	500
2	CSD-6202	Designing Intelligent Agents	4T	500
3	CSD-6203	Social Media Analytics	4T	500
4	CSD-6204	Prompt Engineering Fundamentals	4T	500
5	CSD-6205	Rapid Application Development	4T	500
6	CSD-6206	Programming Paradigms	4T	500
7	CSD-6207	Web Data Analytics	4T	500
Total Credits for GE Courses in Semester IV			**20**	

Discipline Specific Dissertation (DSD)/ Internship (20 Credit Dissertation)				
Sr. No.	**Course Code**	**Title of the Course**	**Credits**	**Level**
1	**CSD-6502**	Dissertation	20	500
Total Credits in Semester IV			**20**	

Blooms Taxonomy Cognitive Levels	
Cognitive Level	**Notations**
K1	Remembering
K2	Understanding
K3	Applying
K4	Analyzing
K5	Evaluating
K6	Create

SEMESTER I

Discipline Specific Core Courses

Title of the Course	Principles of Data Science
Course Code	CSD-5000
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course introduces the foundational principles, processes, and tools of data science, covering the lifecycle from data collection and preprocessing to analysis, modeling, and evaluation.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the data science lifecycle, key concepts, and the interdisciplinary role of a data scientist.	PSO1, PSO2
	CO 2. Apply data preprocessing techniques for cleaning, transforming, and preparing	PSO2, PSO3

	structured and unstructured data.			
	CO 3. Analyze data using descriptive, diagnostic, and predictive techniques, and build simple models using regression and classification.		PSO2, PSO3, PSO4	
	CO 4. Evaluate model performance using appropriate metrics and understand ethical, privacy, and security considerations in data science applications.		PSO3, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Meaning, definition, significance, Role of data scientist, Data Science Process Life Cycle, Challenges in data science process, applications, the significance of domain knowledge in data science, the significance of mathematics in data science	**15**	CO1	K1, K2, K3
Module 2:	Data - information vs data, structured and unstructured data, sources of data, data collection methods. Data preprocessing - cleaning, integration, transformation, reduction, discretization, feature selection and extraction, scaling, normalizing, and dimensionality reduction.	**15**	CO2	K1, K2, K3
Module 3:	Data analysis - descriptive analysis, diagnostic analysis, predictive analysis, exploratory analysis. Model building basics - linear regression, classification, trend analysis. Model Evaluation - accuracy, precision, recall, F1-score.	**15**	CO3	K3, K4
Module 4:	Ethics, bias, and privacy in data science. Information security. Applying data science to real-world problems. Case studies from industry - Business, Healthcare, Finance, Education, Tourism, etc.	**15**	CO4	K1, K4, K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Kelleher, J. D., & Tierney, B. (2018). Data science. MIT Press. 2. Blum, A., Hopcroft, J., & Kannan, R. (2020). Foundations of data science. Cambridge University Press.			

References/ Readings:	1. Pierson, L. (2021). Data science for dummies. John Wiley & Sons. 2. VanderPlas, J. (2016). Python data science handbook: Essential tools for working with data. O'Reilly Media
Web Resources:	OpenStax. (n.d.). Principles of data science. OpenStax. Retrieved May 9, 2025, from https://openstax.org/details/books/principles-data-science

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Title of the Course	Mathematical Foundations for Data Science
Course Code	CSD-5001
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To build a strong mathematical foundational knowledge in probability, statistics, calculus, and linear algebra essential for modeling, analyzing, and solving data-driven problems in data science.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply fundamental principles of probability to understand the uncertainty in data-driven problems.	PSO1, PSO3
	CO 2. To apply statistical inference techniques to analyze and interpret data from both large and small samples	PSO1, PSO2, PSO3
	CO 3. Understand the use of calculus in the mathematical modeling of machine learning algorithms.	PSO1, PSO4
	CO 4. Apply linear algebra concepts to efficiently represent and process data.	PSO1, PSO2, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Probability and Statistics** Basic concepts of probability, conditional probability, law of total probability, independence of events, Bayes' theorem, random variables (discrete and continuous), expectation, moments, moment generating functions, commonly used probability distributions, joint and conditional distributions, transformation of random variables, covariance and correlation. Sampling techniques, sampling distributions.	**15**	CO1	K2, K2, K4
Module 2:	**Advanced Statistics** Parameter estimation, Methods of point estimation, Methods of Interval estimation, hypothesis testing, Large sample tests, Small sample tests, Non-parametric tests.	**15**	CO2	K3, K4, K5
Module 3:	**Calculus** Functions of a single variable, limit, continuity, differentiability, Mean value theorems, indeterminate forms, L'Hospital's rule, Maxima and minima, Product and chain rule, Taylor's series, infinite series summation/integration concepts, Fundamental and mean value-theorems of integral calculus, evaluation of definite and improper integrals, Beta and gamma functions, Functions of multiple variables, limit, continuity, partial derivatives, Basics of ordinary and partial differential equations	**15**	CO3	K2, K3
Module 4:	**Linear Algebra** Representation of vectors and matrices, linear dependence and independence, vector spaces and subspaces (definition, examples, and basis), linear transformations, range and null space, special types of matrices, eigenvalues and eigenvectors, diagonalization, singular value decomposition (SVD), least squares and minimum norm solutions, applications to data analysis.	**15**	CO4	K2, K3, K4
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (2024). Probability and statistical inference 10th Edition, Pearson. 2. Srivastava, M. K., & Srivastava, N. (2009). Statistical Inference: Testing of Hypotheses. PHI Learning Pvt. Ltd..			

	3. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020). Mathematics for machine learning (1st ed.). Cambridge University Press. 4. Nicholson, W. K. (2023). Linear algebra with applications. Boston: PWS Publishing Company.
References/ Readings:	1. Ross, S. M. (2020). A first course in probability. Pearson. 2. Casella, G., & Berger, R. (2024). Statistical inference. CRC Press. 3. Strang, G. (2022). Introduction to linear algebra. Wellesley-Cambridge Press.
Web Resources:	MIT OpenCourseWare. (n.d.). Linear algebra [Video series]. Massachusetts Institute of Technology. Retrieved May 10, 2025, from https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/video_galleries/video-lectures/

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Title of the Course	Problem Solving and Programming Fundamentals
Course Code	CSD-5002
Number of Credits	2
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip learners with foundational concepts and programming skills necessary for designing and implementing solutions to data-intensive problems using appropriate tools, techniques, and data structures in data science.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the fundamental concepts of problem-solving and programming constructs such as algorithms, flowcharts, and pseudocode.	PSO1
	CO 2. Apply structured problem-solving techniques to develop algorithmic solutions using appropriate control structures.	PSO1, PSO2
	CO 3. Design and represent solutions to computational problems using flowcharts, pseudocode, and basic data structures.	PSO1, PSO3
	CO 4. Analyze problem scenarios to design, test, and refine modular and structured solutions	PSO1, PSO3, PSO6

	using programming tools.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Problem Solving Basics:** Problem-solving process; Identifying solution types; Approaches for solving problems using computers. Constants, variables, data types, and functions. Operators, expressions, and equations used in problem-solving. **Solution Planning and Design:** Communicating with the computer; Tools for planning solutions (flowcharts, pseudocode). Introduction to the Software Development Life Cycle (SDLC). **Techniques of Problem Solving:** Sequential Problem Solving: Using flowcharts, algorithmic instructions, and pseudocode. Decision Problem Solving: Logic types, decision tables. Iterative Problem Solving: Loops, recursion, incrementing & accumulating, types of loops.	**15**	CO1 CO2 CO3	K2, K3
Module 2:	**Composite Data Structures:** Introduction to lists, arrays, and maps (one-dimensional, two-dimensional arrays), Basic concepts of linked lists, graphs, and trees. Database and File Handling: Introduction to DBMS and file processing concepts. **Learning by Tools:** Using tools like PictoBlox, Scratch, TurtleArt, and programming languages like Kojo and Racket (DrRacket); Hands-on assignments: Create geometric shapes, solve arithmetic problems like factorials, prime numbers, etc.	**15**	CO3 CO4	K3, K4
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Felleisen, M., Findler, R. B., Flatt, M., & Krishnamurthi, S. (2018). How to design programs: an introduction to			

	programming and computing. MIT Press.
References/ Readings:	1. Abelson, H., & Sussman, G. J. (1996). Structure and interpretation of computer programs (p. 688). The MIT Press. 2. Maureen Sprankle, Jim Hubbard (2013). Problem Solving and Programming Concepts. Pearson Education India. Latest Edition. 3. Kuppuswamy, S., Malliga, S., Kanimozhi Selvi, C. S., & KousaIya, K. (2019). Problem Solving and Programming. Tata McGraw Hill.
Web Resources:	Felleisen, M., Findler, R. B., Flatt, M., & Krishnamurthi, S. (2001). How to design programs. Retrieved May 9, 2025, from https://htdp.org/

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Title of the Course	Data Science Lab
Course Code	CSD-5003
Number of Credits	3
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide hands-on experience in Python programming, data analysis, and database management, empowering students to use Python libraries, build applications, and perform SQL queries for solving real-world data science problems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply Python programming concepts to solve real-world problems, including the use of control structures, functions, recursion, and object-oriented programming.	PSO1, PSO2, PSO3
	CO 2. Analyze and manipulate datasets using Python libraries to perform data cleaning, transformation, and visualization.	PSO2, PSO3, PSO5
	CO 3. Design and develop interactive applications using Streamlit, Flask, and Django to present data-driven insights.	PSO2, PSO3, PSO5, PSO6

	CO 4. Evaluate and perform SQL queries to manage, retrieve, and analyze data from relational databases.		PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Programming in Python 1. Set up a UNIX/Python environment to run and manage Python programs. 2. Implement code collaboration workflows using Git for version control. 3. Practice decision-making, branching, and looping constructs using control structures. 4. Work with Python data types including lists, sets, tuples, dictionaries, and strings. 5. Implement user-defined functions and recursive solutions for computational problems. 6. Create and manipulate user-defined data types and perform file handling operations. 7. Perform CRUD operations using text files for data storage and retrieval. 8. Create a custom data type using classes and objects in Python. 9. Implement unit testing to verify the correctness and robustness of Python code.	**30**	CO1	K3, K4
Module 2:	Python Libraries, Packages, Frameworks 1. Use Pandas library to handle, clean, and manipulate structured data. 2. Work with Python packages for loading and preprocessing real-world datasets. 3. Apply time-series analysis techniques to explore temporal patterns in data. 4. Visualize data using various plots, charts, and graphs to uncover insights. 5. Develop interactive data-driven applications using Streamlit. 6. Build and deploy simple web applications using the Flask framework. 7. Create scalable and structured web applications using the Django framework.	**30**	CO2 CO3	K4. K5
Module 3:	Querying Data (SQL) 1. Set up a relational database and create, modify tables with appropriate constraints. 2. Query and explore metadata to understand the structure and schema of a database.	**30**	CO4	K4. K5

	3. Perform CRUD operations to insert, update, delete, and retrieve data from tables. 4. Retrieve specific data using operators, wildcards, sorting, and built-in SQL functions. 5. Use joins, aggregate functions, grouping, and sub-queries to analyze and summarize data.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	1. Sweigart, A. (2019). Automate the boring stuff with Python: Practical programming for total beginners (2nd ed.). No Starch Press. 2. Beaulieu, A. (2009). Learning SQL. O'Reilly Media. Latest Edition.			
References/ Readings:	1. McKinney, W. (2017). Python for data analysis: Data wrangling with pandas, numpy, and ipython (2nd ed.). O'Reilly Media. 2. Garcia-Molina, H. (2008). Database systems: the complete book. Pearson Education India.			
Web Resources:	1. Data.World. (n.d.). Introduction to SQL concepts. Data.World. Retrieved May 9, 2025, from https://docs.data.world/documentation/sql/concepts/basic/intro.html 2. TutorialsPoint. (n.d.). SQL tutorial. TutorialsPoint. Retrieved May 9, 2025, from https://www.tutorialspoint.com/sql/index.htm 3. SQLZoo. (n.d.). SQL tutorial. SQLZoo. Retrieved May 9, 2025, from https://sqlzoo.net/wiki/SQL_Tutorial 4. Python Software Foundation. (n.d.). Python documentation. Python.org. Retrieved May 9, 2025, from https://docs.python.org/3/ 5. Streamlit Inc. (n.d.). Streamlit documentation. Streamlit. Retrieved May 9, 2025, from https://docs.streamlit.io/ 6. Pallets Projects. (n.d.). Flask tutorial. Flask Documentation. Retrieved May 9, 2025, from https://flask.palletsprojects.com/en/stable/tutorial/ 7. Django Software Foundation. (n.d.). Django documentation. Django. Retrieved May 9, 2025, from https://docs.djangoproject.com/			

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Title of the Course	Mathematical Foundations for Data Science Lab
Course Code	CSD-5004
Number of Credits	3
Theory/Practical	Practical
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To provide hands-on experience in implementing foundational mathematical and statistical concepts through computational tools for data analysis, visualization, inference, and dimensionality reduction on real-world datasets.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Simulate and visualize probabilistic models and distributions using computational tools.		PSO1	
	CO 2. Apply sampling techniques on real-world datasets and interpret the results.		PSO1, PSO2	
	CO 3. Perform hypothesis testing and draw statistical inferences on real world data.		PSO1, PSO2	
	CO 4. Implement dimensionality reduction techniques on real world dataset		PSO1, PSO2	
Content:	Use Python libraries such as NumPy, SciPy, Pandas, Matplotlib, Seaborn to perform the following experiments:	**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	1. Simulate basic probability experiments to apply conditional probability and total probability. 2. Visualize probability distributions and explore their properties. 3. Implement various sampling techniques on real world data. 4. Using the chi-square test, check goodness-of-fit and test of independence.	**30**	CO1, CO2	K2, K3
Module 2:	1. Perform Z-test and t-test for single population mean. 2. Implement One-sample and two-sample t-tests 3. Perform F-test and Levene's test to compare variances	**30**	CO3	K2, K3
Module 3:	1. Represent a real world dataset as vectors or matrices. Perform linear transformations and visualize them. 2. Implement Principal Component Analysis and reduce the dimensionality of a real world dataset 3. Implement Singular Value Decompositions and reduce the dimensionality of a real world dataset.	**30**	CO4	K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	1. Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (2024). Probability and statistical inference 10th Edition, Pearson. 2. Srivastava, M. K., & Srivastava, N. (2009). Statistical Inference: Testing of Hypotheses. PHI Learning Pvt. Ltd.. 3. Deisenroth, M. P., Faisal, A. A., & Ong, C. S. (2020). Mathematics for machine learning (1st ed.). Cambridge University Press. 4. Nicholson, W. K. (2023). Linear algebra with applications. Boston: PWS Publishing Company.			
References/ Readings:	1. Downey, A. (2014). Think stats: Exploratory data analysis. 2nd Edition " O'Reilly Media, Inc.". 2. Wes, M. (2017). Python for data analysis. 2nd Edition " O'Reilly Media, Inc.".			
Web Resources:	1. Statquest. (n.d.). Statistics fundamentals [YouTube playlist]. YouTube. Retrieved May 10, 2025, from			

	https://www.youtube.com/playlist?list=PLblh5JKOoLUK0FLuzwntyYI10UQFUhsY9 2. 3Blue1Brown. (n.d.). Essence of linear algebra [YouTube playlist]. YouTube. Retrieved May 10, 2025, from https://www.youtube.com/playlist?list=PLZHQObOWTQDPD3MizzM2xVFitgF8hE_ab 3. MIT OpenCourseWare. (n.d.). Linear algebra [Video series]. Massachusetts Institute of Technology. Retrieved May 10, 2025, from https://ocw.mit.edu/courses/18-06-linear-algebra-spring-2010/video_galleries/video-lectures/

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Discipline Specific Elective Courses

Title of the Course	Data Management
Course Code	CSD-5201
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to equip students with the knowledge of relational and non-relational database systems, data modeling, data retrieval techniques, and modern data storage paradigms, including NoSQL and in-memory databases.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the structure, types, and lifecycle of data in the context of data science workflows.	PSO1, PSO2
	CO 2. Analyze and apply database design principles using entity-relationship modeling and relational schema translation.	PSO1, PSO3
	CO 3. Apply normalization techniques to design efficient and consistent relational databases.	PSO1, PSO3

	CO 4. Construct and optimize SQL queries for data retrieval, aggregation, and manipulation.		PSO2, PSO3	
	CO 5. Explain the concepts and applications of transactions, indexing, and query optimization in relational databases.		PSO1, PSO3	
	CO 6. Compare relational databases with NoSQL and in-memory databases, identifying their appropriate use cases in data science applications.		PSO1, PSO2, PSO3	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Foundations of Data Management: Data and Information, Hierarchy of Data (Bit, Byte, Field, Record, File, Database), Data Types and Representations (Structured, Semi-structured, Unstructured) Data Lifecycle and Workflow in Data Science Data Handling Tools in Data Science, Data Storage and Retrieval, Data Security, Access Control, and Privacy Considerations	**15**	CO1	K1, K2
Module 2:	Database Design and Relational Modeling: Database Concepts and Terminology, Data Models, ER Modeling and ER Diagrams, Translating ER Models to Relational Schemas Relational Model: Tables, Keys, Integrity Constraints Functional Dependencies, Normalization: 1NF, 2NF, 3NF	**15**	CO2, CO3	K2, K3, K4
Module 3:	Data Retrieval and Query Processing: SQL Basics: SELECT, WHERE, ORDER BY, GROUP BY Advanced Queries: JOINs (INNER, OUTER, SELF), Subqueries Aggregate Functions, GROUP BY and HAVING Clauses Views, Indexes, and Stored Procedures Transactions and ACID Properties; Query Optimization Basics	**15**	CO4, CO5	K2, K3, K4
Module 4:	NoSQL and In-Memory Databases: NoSQL Data Models, NoSQL vs SQL, Basics of Data Replication and Sharding, CAP	**15**	CO6	K2, K4, K5

	Theorem and BASE vs ACID In-Memory Databases: Concept, Use Cases, and Performance			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Silberschatz, A., Korth, H. F., & Sudarshan, S. (2020). Database system concepts (7th ed.). McGraw-Hill Education. 2. Kleppmann, M. (2017). Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. O'Reilly Media.			
References/ Readings:	Elmasri, R., & Navathe, S. B. (2017). Fundamentals of database systems (7th ed.). Pearson Education.			
Web Resources:	MIT OpenCourseWare - Database Systems (2018). Retrieved on May 13, 2025, from https://ocw.mit.edu/courses/6-830-database-systems-fall-2010/			

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Title of the Course	Algorithms and Computational Complexity
Course Code	CSD-5202
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce the fundamental principles of algorithmic problem solving, including complexity analysis, searching, sorting, and algorithmic strategies relevant to data science.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand fundamental algorithmic concepts, time and space complexity, and recursive structures.	PSO1, PSO2
	CO 2. Apply searching and sorting algorithms to solve basic data-centric problems.	PSO2, PSO3
	CO 3. Utilize appropriate data structures and graph algorithms to address computation-heavy tasks.	PSO3
	CO 4. Analyze and implement algorithmic design strategies like greedy, divide-and-conquer, and dynamic programming.	PSO2, PSO3

	CO 5. Evaluate the efficiency and scalability of string matching algorithms, hashing techniques, and heap-based algorithms for real-world data science applications.		PSO4, PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Foundations of Algorithms and Complexity:** Introduction to Algorithms: Definition, characteristics, and importance in data science Algorithm Representation: Pseudocode, flowcharts Time and Space Complexity: Big O, Big Theta, Big Omega Recursion and Recursive Algorithms Searching Algorithms: Linear Search, Binary Search Sorting Algorithms: Bubble, Selection, Insertion, Merge Sort, Quick Sort Stability and Efficiency of Sorting Algorithms	**15**	CO1, CO2	K2, K3
Module 2:	**Advanced Data Structures and Graph Algorithms:** Linear Data Structures: Arrays, Stacks, Queues. Non-Linear Data Structures: Trees, Graphs Graph Representations: Adjacency list/matrix Graph Traversal Algorithms: Breadth-First Search (BFS), Depth-First Search (DFS)	**15**	CO3	K3, K4
Module 3:	**Algorithm Design Techniques** Greedy Algorithms: Principle, examples (knapsack problem) Divide and Conquer: Concept and examples (merge sort, binary search) Dynamic Programming: Overlapping subproblems and optimal substructure (e.g., knapsack problem) Backtracking and Branch and Bound (e.g., N-Queens, TSP introduction)	**15**	CO4	K3, K4

Module 4:	**Algorithm Applications in Data Science** String Matching Algorithms: KMP Hashing Techniques and Hash Functions Introduction to Heaps and Priority Queues Case Studies: Algorithmic Applications in Data Science	**15**	CO5	K3, K4, K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Cormen, T. H., Leiserson, C. E., Rivest, R. L., & Stein, C. (2009). *Introduction to algorithms* (3rd ed.). MIT Press.			
References/ Readings:	1. Skiena, S. S. (2020). The algorithm design manual (3rd ed.). Springer. 2. Goodrich, M. T., Tamassia, R., & Goldwasser, M. H. (2013). *Data structures and algorithms in Python*. Wiley. 3. Kleinberg, J., & Tardos, É. (2006). *Algorithm design*. Pearson Education.			
Web Resources:	1. MIT OpenCourseWare- Introduction to Algorithms. Retrieved May 13, 2025, from https://ocw.mit.edu/courses/6-006-introduction-to-algorithms-spring-2020/			

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SEMESTER II

Discipline Specific Core Courses

Title of the Course	Machine Learning Techniques
Course Code	CSD-5005
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5001	
Course Objectives:	To equip students to understand and apply key machine learning techniques—such as classification, regression, clustering, neural networks, and reinforcement learning—to analyze data and solve real-world problems.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand key concepts, types, and applications of machine learning algorithms.	PSO1, PSO2
	CO 2. Apply supervised learning techniques to classification and regression problems.	PSO2, PSO3
	CO 3. Analyze model performance and perform evaluation and tuning using appropriate	PSO2, PSO4

	metrics.			
	CO 4. Implement and interpret basic neural networks, deep learning models, and clustering techniques.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Definition of Learning Systems, Applications of Machine Learning, Types of Machine Learning: Supervised, Unsupervised, and Reinforcement Learning; Linear Regression: Simple Linear Regression, Multiple Linear Regression, Cost Function, Gradient Descent Optimization. Logistic Regression: Introduction and use in classification problems, Sigmoid Function, Cost Function and Optimization (Gradient Descent) Model Evaluation metrics: Classification Metrics: Accuracy, Precision, Recall, F1-Score, Confusion Matrix, ROC Curve, AUC Regression Metrics: MSE, R^2	**15**	CO1, CO2	K2, K3, K4
Module 2:	Tree-Based and Kernel Methods: Decision Trees: Splitting, Overfitting, Pruning Support Vector Machines (SVM): Introduction, Linear, Kernel Trick, Soft Margin Ensemble Methods- Bagging: Random Forest Boosting: AdaBoost, Gradient Boosting (conceptual focus) Comparison and Evaluation of Ensemble Techniques Model Validation Techniques-k-Fold Cross-Validation, Bias-Variance Tradeoff, Overfitting and Underfitting	**15**	CO2, CO3,	K2, K3, K4
Module 3:	Unsupervised Learning: Clustering: K-means Clustering Algorithm, Hierarchical Clustering Principal Component Analysis (PCA): Introduction, Covariance Matrix and Eigenvalues, Dimensionality Reduction	15	CO3, CO4	K2, K3, K4

	Neural Networks: Introduction, Perceptron Model, Feedforward Neural Network Architecture, Activation Functions: Sigmoid, ReLU, Tanh, Gradient Descent and Backpropagation, Training Neural Networks: Cost Functions, Optimizers Deep Learning: Introduction, Architecture of Deep Networks, Convolutional Neural Networks (CNN), Recurrent Neural Networks (RNN) and LSTM			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments//Flipped classroom			
Texts:	Alpaydin, E. (2020). Introduction to machine learning. MIT press, 4th Edition (or latest)			
References/ Readings:	1. Mitchell, T. M., (1997). Machine learning (Vol. 1, No. 9). New York: McGraw-hill. 2. Bishop, C. M. (2006). Pattern recognition and machine learning: springer New York.. 3. Flach, P. (2012). Machine learning: the art and science of algorithms that make sense of data. Cambridge university press. 4. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press. 5. Hart, Peter E., David G. Stork, and Richard O. Duda.(2000) Pattern classification. Hoboken: Wiley, 2000. 6. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning (Vol. 112, p. 18). New York: springer.			
Web Resources:	1. MIT course on Introduction to Machine Learning. Retrieved on 27th May 2025, from: https://openlearninglibrary.mit.edu/courses/course-v1:MITx+6.036+1T2019/about			

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Title of the Course	Data Modeling and Visualization
Course Code	CSD-5006
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To analyze and interpret data throughout the data management lifecycle using appropriate analysis methods.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand and apply core data modeling concepts, including entities, relationships, constraints, and cardinalities.	PSO1, PSO3
	CO 2. Analyze and model real-world data complexities using strong/weak entities and relationship hierarchies.	PSO5
	CO 3. Explain the role of data visualization in analysis and decision-making, and distinguish between visualization types.	PSO1, PSO5
	CO 4. Create effective visualizations for various data types using appropriate techniques and	PSO5

	best practices.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	Data modelling- basic data modeling concepts and terminology, data modeling building blocks- hierarchies for the entities, data model Constraints for your attributes: specify cross-entity dependencies through strong and weak entities - summary of real-world entity and attributes complexities. real-world complexities to relationships why relationship cardinality and complexities matter - build real-world complexities into data model relationships-define the maximum cardinality of a relationship -define the minimum cardinality of relationship -use crow's foot notation for minimum and maximum cardinality -summary of cardinality and complex relationships. Introduction to Data Visualization: What is Data Visualization? Importance in Data Analysis and Decision Making. Components of Data Visualization: Data, Visual Encoding, Interaction, and Context. Types of Data Visualization: Static vs. Interactive Visualizations. Common types of charts: Bar Charts, Line Charts, Pie Charts, Histograms, Scatter Plots, Heatmaps. Visualization Best Practices: Effective use of color, labels, scales, and legends. Avoiding common pitfalls (misleading scales, cluttered visuals).	**15**	CO1, CO2, CO3	K1, K2, K3, K4
Module 2:	Visualizing Univariate and Bivariate Data: Visualizing Univariate Data: Histograms, Box Plots. Distribution of Data: Skewness, Kurtosis. Visualizing Bivariate Data: Scatter Plots, Heatmaps. Correlation, Trend Lines, and Regression. Introduction to Pair Plots and Correlation Matrices. Advanced Visualizations: Line Plots, Area Charts, and Time Series Decomposition. Understanding Trends, Seasonality, and Noise in Time Series Data. Geospatial Data Visualization: Mapping data with Geographic Information Systems (GIS). Visualizing location-based data using choropleth maps and bubble maps.	**15**	CO3, CO4	K1, K2, K3, K4

Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom
Texts:	1. Connolly, T., & Begg, C. (6th edition). Database systems: A practical approach to design, implementation, and management. Pearson Education. 2. Healy, K. (2018). Data visualization: A practical introduction. Princeton University Press.
References/ Readings:	1. Hoberman, S. (2009). Data modeling made simple: A practical guide for business and IT professionals (2nd ed.). Technics Publications. 2. Tufte, E. R. (2001). The visual display of quantitative information (2nd ed.). Graphics Press. 3. Tufte, E. R., Goeler, N. H., & Benson, R. (1990). Envisioning information (Vol. 2). Graphics Press. 4. Fry, B. (2008). Visualizing data: Exploring and explaining data with the processing environment. O'Reilly Media, Inc.

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Title of the Course	Internet of Things
Course Code	CSD-5007
Number of Credits	2
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5002			
Course Objectives:	To introduce the fundamentals of the Internet of Things (IoT), its components, and basic data analytics techniques for collecting, processing, and analyzing sensor data using simple IoT platforms and tools.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Understand IoT concepts, architectures, sensors, actuators, and development boards.		PSO1, PSO2, PSO3	
	CO 2. Demonstrate basic sensor interfacing and data communication using microcontrollers and cloud platforms.		PSO1, PSO2	
	CO 3. Apply basic data analysis and visualization techniques to IoT datasets.		PSO2, PSO3, PSO5	
	CO 4. Design a simple IoT application integrating sensing, cloud storage, and analytics.		PSO2, PSO3, PSO7, PSO8	
Content:		**No of**	**Mapped**	**Cognitive**

		hours	to CO	Level
Module 1:	Fundamentals of Internet of Things: ● Introduction to IoT – Concept, features, and applications ● IoT architecture and components – Things, sensors, microcontrollers, cloud ● Sensors and actuators – types and basic interfacing ● Microcontrollers – overview of Arduino and ESP32 ● Communication and networking in IoT – overview of protocols (MQTT, HTTP, CoAP) ● IoT and cloud – sending data to cloud platforms (ThingSpeak / Firebase) ● IoT challenges – power, communication, privacy, and security basics	**15**	CO1, CO2	K2, K3, K4
Module 2:	IoT Data and Applications: ● IoT data – types, collection, and storage ● Simple data processing and visualization ● Introduction to IoT data analytics – cleaning, summarizing, and plotting data ● Using Python for IoT data analysis (Pandas / Matplotlib) ● Real-time visualization using ThingSpeak or Grafana ● Case studies – smart home, health monitoring, weather station	**15**	CO3, CO4	K2, K3, K4, K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Raj, P., & Raman, A. C. (2017). The Internet of Things: Enabling technologies, platforms, and use cases. Auerbach Publications. 2. Bahga, A., & Madisetti, V. (2014). Internet of Things: A hands-on approach. Vpt. 3. Dunn, P. F. (2011). Fundamentals of sensors for engineering and science. Crc Press.			
References/ Readings:	1. Qureshi, K. N., & Newe, T. (Eds.). (2024). Artificial intelligence of things (AIoT): new standards, technologies and communication systems. CRC Press. 2. Choset, H., Lynch, K. M., Hutchinson, S., Kantor, G. A., & Burgard, W. (2005). Principles of robot motion: theory, algorithms, and implementations. MIT press.			

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Title of the Course	Optimization Techniques
Course Code	CSD-5008
Number of Credits	3
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5001	
Course Objectives:	To provide students with a comprehensive understanding of Optimization techniques and their practical applications in decision-making.	
Course Outcomes:		**Mapped to PSO**
	CO 1. To introduce Operations Research concepts for data-driven decision-making.	PSO1
	CO 2. To develop skills in modeling and optimizing real-world problems using quantitative methods.	PSO2
	CO 3. To apply OR techniques to enhance data analysis, prediction, and optimization in data science contexts.	PSO3
	CO 4. To integrate analytical models with data science tools for informed and efficient decision-making.	PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	**Introduction to Operations Research** Mathematical models, Scope and applications, Phases of Operation Research study, Characteristics, Limitations of Operation Research. **Linear Programming** Introduction, Properties of Linear Programming, Basic assumptions, Mathematical formulation of Linear Programming, Limitations or constraints, Methods for the solution of LP Problem, Graphical analysis of LP, Graphical LP, Maximization problem, Graphical LP Minimization problem. **Linear Programming Models** Simplex Method, Basics of Simplex Method, Formulating the Simplex Method, Simplex Method with two variables, Simplex Method with more than two variables, Big M Method.	**15**	CO1, CO2,	K1, K2, K3
Module 2:	**Dual Linear Programming** Introduction, Primal and Dual problem, Dual problem properties, Solution techniques of Dual problem, Dual Simplex method, Relations between direct and dual problem, Economic interpretation of Duality. **Transportation and Assignment Models** Introduction, Transportation problem, Balanced, Unbalanced, Methods of basic feasible solution Optimal solution, MODI method, Assignment problem, Hungarian Method.	**15**	CO3	K2, K3, K4
Module 3:	**Network Analysis** Basic concepts, Construction of Network, Rules and precautions CPM and PERT	**15**	CO4	K2, K3, K4

	Networks Obtaining critical path, Probability and cost consideration, Advantages of Network. **Theory of Games** Introduction, Terminology, Two Person Zero-Sum game, Solution of games with saddle points and without saddle points, 2X2 games, dominance principle, mX2 and 2Xn games, Graphical method. **Industry Perspective** Research and Analytical problems on various applications of the industrial issues.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Gupta, P. K., & Hira, D. S. (2022). Introduction to Operations Research. S. Chand Publishing.			
References/ Readings:	1. J K Sharma (2007), Operations Research Theory & Applications, 3e, Macmillan India Ltd. 2. Maurice Solient, Arthur Yaspen, Lawrence Fridman, OR methods and Problems (2003), New Age International Edition. 3. P. SankaraIyer, (2008), Operations Research, Tata McGraw-Hill. 4. Philips, D. T. (2007). Operations research: Principles and practice. John Wiley & Sons, Incorporated. 5. S.D. Sharma (2000). Operations Research. Nath& Co., Meerut.			
Web Resources:	1. MIT course on Optimization Methods. Retrieved on 27th May 2025, from: Optimization Methods | Sloan School of Management | MIT OpenCourseWare			

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Title of the Course	Machine Learning Techniques Lab
Course Code	CSD-5009
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5002, CSD-5003	
Course Objectives:	To equip students with practical skills to implement, evaluate, and apply machine learning algorithms using real-world data, fostering analytical thinking and hands-on experience through tools and mini-projects.	
Course Outcomes:		**Mapped to PSO**
	CO 1. To develop hands-on proficiency in implementing core machine learning algorithms and evaluating their performance using real-world datasets.	PSO 1, PSO 2, PSO 4
	CO 2. To equip students with the ability to preprocess data and apply appropriate supervised and unsupervised learning techniques.	PSO 2, PSO 3, PSO 4
	CO 3. To enable practical understanding of dimensionality reduction techniques and model evaluation methods through coding exercises and experiments.	PSO 2, PSO 3, PSO 4
	CO 4. To foster problem-solving and model-building skills by engaging in a mini-project using	PSO 2, PSO 3, PSO 4,

	machine learning tools and libraries.		PSO 6, PSO 8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	1. Implement and evaluate a Decision Tree classifier using a real-world dataset. 2. Train a Random Forest classifier and compare accuracy with a Decision Tree on the same dataset. 3. Perform Simple Linear Regression on a dataset and evaluate using MSE and R^2. 4. Implement Multiple Linear Regression and interpret the results. 5. Train a Logistic Regression model on a binary classification dataset and evaluate with accuracy and confusion matrix. 6. Implement a Support Vector Machine (SVM) for classification using linear kernel and analyze results. 7. Apply K-fold cross-validation to any one classification model and report accuracy variance across folds.	**30**	CO1, CO2	K3, K4, K5
Module 2:	1. Apply K-means clustering to a dataset and visualize the resulting clusters. 2. Perform dimensionality reduction using Principal Component Analysis and visualize the transformed data. 3. Fit a Gaussian Mixture Model (GMM) and compare with K-means clustering on the same dataset. 4. Build and train a feedforward neural network for digit classification using a standard dataset. 5. Implement a Convolutional Neural Network (CNN) and evaluate its performance on an image dataset. 6. Mini Project: Design and implement a machine learning based mini project on a real-world dataset, involving model training, evaluation, and visualization.	**30**	CO2, CO3, CO4	K3, K4, K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	Alpaydin, E. (2020). Introduction to machine learning. MIT press, 4th Edition (or latest)			

References/ Readings:	1. Mitchell, T. M., (1997). Machine learning (Vol. 1, No. 9). New York: McGraw-hill. 2. Bishop, C. M. (2006). Pattern recognition and machine learning: springer New York. 3. Flach, P. (2012). Machine learning: the art and science of algorithms that make sense of data. Cambridge university press. 4. Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT press.
Web Resources:	1. Machine Learning tutorial retrieved on 27th May 2025 from: https://www.w3schools.com/python/python_ml_getting_started.asp 2. Machine Learning with Python retrieved on 27th May 2025 from: https://www.freecodecamp.org/learn/machine-learning-with-python/

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Title of the Course	Data Modeling and Visualization Lab
Course Code	CSD-5010
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil			
Course Objectives:	To design effective visualizations using best practices and tools like GapMinder and Tableau for clear, impactful data communication.			
Course Outcomes:			**Mapped to PSO**	
	CO 1. Design entity-relationship diagrams with proper entities, attributes, and cardinalities.		PSO1, PSO2	
	CO 2. Convert data models into normalized relational schemas using database tools..		PSO2, PSO3	
	CO 3. Create effective visualizations for univariate, bivariate, and time-series data.		PSO2, PSO5	
	CO 4. Interpret and communicate data insights using best visualization practices.		PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**

Module 1:	1. To crreate Entity-Relationship (ER) Diagrams using Crow's Foot notation; Practice defining strong and weak entities. 2. To define and apply cardinality (min/max) constraints in relationships; Model real-world complexities. 3. To translate ER diagrams into Relational Schemas; Normalize data to 3NF. 4. To use a database design tool (e.g., MySQL Workbench, dbdiagram.io) to create and visualize models.	**30**	CO1, CO2	K3, K4, K6
Module 2:	1. Introduction to visualization tools (e.g., Tableau, Power BI, or Python libraries like matplotlib/seaborn). 2. To create basic charts: bar charts, line charts, pie charts, histograms using sample datasets. 3. to visualize univariate data: Histograms, box plots; Understand skewness and kurtosis visually. 4. to visualize bivariate data: scatter plots, heatmaps; Explore correlation and trend lines.	**30**	CO3, CO4	K3, K4, K6
Pedagogy:	Tutorials/Hands-on Lab assignments/Flipped classroom/Mini-project			
Texts:	1. Connolly, T., & Begg, C. (6th edition). Database systems: A practical approach to design, implementation, and management. Pearson Education. 2. Healy, K. (2018). Data visualization: A practical introduction. Princeton University Press.			
References/ Readings:	1. Hoberman, Steve. Data modeling made simple: a practical guide for business and IT professionals. Technics Publications, 2nd Edition 2009. 2. Edward Tufte, The Visual Display of Quantitative Information 2nd Edition, 2001 3. Tufte, Edward R., Nora Hillman Goeler, and Richard Benson. Envisioning information. Vol. 2. Cheshire, CT: Graphics press, 1990. 4. Fry, Ben. Visualizing data: Exploring and explaining data with the processing environment. " O'Reilly Media, Inc.", 1st Edition 2008.			

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Title of the Course	Internet of Things Lab
Course Code	CSD-5011
Number of Credits	2
Theory/Practical	Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5002, CSD-5003	
Course Objectives:	To provide practical knowledge of the Internet of Things (IoT) by integrating sensors, microcontrollers, and cloud platforms to design real-time data-driven applications.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Build simple IoT systems using sensors and microcontrollers to collect and send data.	PSO1, PSO2, PSO5, PSO8.
	CO 2. Apply IoT concepts to create automated solutions for real-world problems.	PSO2, PSO3, PSO4, PSO6.
	CO 3. Develop IoT applications that connect devices, process data, and display results through apps or dashboards.	PSO2, PSO4, PSO5, PSO8
	CO 4. Build project to design and test a complete IoT-based solution.	PSO3, PSO6, PSO7,

			PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	List of suggested practicals: 1. Learn Arduino/ESP32 programming by controlling LEDs, reading ambient light with an LDR, and measuring distance using an ultrasonic sensor. 2. Create a temperature and humidity monitoring system that logs sensor data to a cloud platform (ThingSpeak, Firebase, or AWS IoT) in real-time and visualizes it. 3. Build an automated plant irrigation system that waters plants based on soil moisture readings. 4. Develop a home automation prototype to control lights and fans remotely via a mobile app or web interface. 5. Design a smart parking system that detects vehicle presence, indicates parking availability with LEDs, and shows availability on a mobile app or web interface. 6. Develop a health monitoring system that measures heart rate and body temperature and sends alerts if abnormal values are detected. 7. Develop a decision tree classifier using the temperature and humidity dataset collected from the IoT cloud monitoring system (Exp 2/4) to predict environmental conditions or anomalies. 8. Train a machine learning model to predict equipment failure using vibration and temperature data. 9. Develop an AI-enabled smart irrigation system that optimizes watering schedules based on soil moisture and weather data. 10. Visualize IoT sensor data with graphs and charts to identify trends and anomalies.	**30**	CO1, CO2	K2, K3, K4, K5
Module 2:	1. Create a dashboard or mobile app that collects data from IoT sensors and displays real-time health or environmental insights. 2. Build a Smart Dustbin that automatically detects garbage levels and notifies collection requirements via a mobile app.	**30**	CO3, CO4	K2, K3, K4, K5

	3. Develop an obstacle-avoidance robot that navigates around objects autonomously using sensors. 4. Construct a fire-fighting robot prototype that detects flame or smoke and autonomously moves toward it to activate a water pump. 5. Implement an image recognition system that identifies objects or people using a camera and AI model. 6. Mini Project			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Bahga, A., & Madisetti, V. (2014). Internet of Things: A hands-on approach. Vpt. 2. Blum, J. (2019). Exploring Arduino: tools and techniques for engineering wizardry. John Wiley & Sons. 3. Monk, S. (2022). Raspberry pi cookbook. " O'Reilly Media, Inc.". 4. Warden, P., & Situnayake, D. (2019). Tinyml: Machine learning with tensorflow lite on arduino and ultra-low-power microcontrollers. O'Reilly Media. 5. Géron, A. (2022). Hands-on machine learning with Scikit-Learn, Keras, and TensorFlow. " O'Reilly Media, Inc.".			
Web Resources:	1. Arduino official docs & tutorials available at https://docs.arduino.cc/tutorials/ (accessed on 3rd Oct 2025.) 2. Espressif (ESP32) documentation & examples available at https://docs.espressif.com/projects/esp-idf/en/stable/esp32/index.html (accessed on 3rd Oct 2025) 3. Raspberry Pi Foundation docs available at https://www.raspberrypi.org/learn/ (accessed on 3rd Oct 2025.) 4. ThingSpeak / Firebase / AWS IoT Core docs available at https://docs.aws.amazon.com/iot/ (accessed on 3rd Oct 2025.) 5. MQTT protocol tutorials available at https://www.hivemq.com/blog/how-to-get-started-with-mqtt/ (accessed on 3rd Oct 2025.)			

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Discipline Specific Elective Courses

Title of the Course	Domain-Specific Predictive Analytics
Course Code	CSD-5203
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide a comprehensive theoretical foundation in predictive modeling techniques, with a focus on their application across various real-world domains.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Develop a strong foundation of the core concepts of predictive modeling.	PSO1
	CO 2. Understand the key features for predictive models for financial data.	PSO3, PSO4
	CO 3. Compare the machine learning models for clinical prediction and fraud detection in Healthcare.	PSO3, PSO4
	CO 4. Use the predictive models for customer and market analysis.	PSO3, PSO4

	CO 5. Gain insights on the application of machine learning models in social media analytics.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Module 1:	**Introduction** Prediction vs Interpretation, Key ingredients of predictive models, Predictive modeling process, Linear and Non-linear regression models, Linear and Non-linear classification models, Class imbalance problem. **Finance Domain** Financial Data Structures, Labeling and Meta-Labeling, Sample Weights, Structural Breaks, Entropy Features, Microstructural Features, Ensemble Methods, Cross-Validation in Finance, Feature Importance, Hyper-Parameter Tuning, Backtesting.	**15**	CO1, CO2	K2, K3
Module 2:	**Healthcare Domain** Healthcare Data Sources, Challenges in Healthcare Data Analysis, Clinical Prediction Models - Linear Regression, Logistic Regression, Bayesian Models, Neural Networks, Cost-Sensitive Learning, Multiple Instance Learning, Sparse Methods, Kernel Methods, Fraud detection in Healthcare.	**15**	CO3	K2, K3
Module 3:	**Marketing Domain** Understanding Markets, Building customer profiles, Managing customer portfolio, Predicting customer personas, Predicting customer journey, Predicting customer value, Predicting likelihood to buy, Predicting customer choice, Targeting current customers, Finding new customers, Retaining customers, Positioning and Promoting products, Recommending products.	**15**	CO4	K2, K3
Module 4:	**Social Media Domain** Social media prediction, Network measures, Network models, Properties of Real-World Networks, Modeling Real World Networks with Random Graphs, Small World Model, Preferential Attachment Model, Community Detection, Evolution and Evaluation, Information diffusion in Social Media.	**15**	CO5	K2, K3

Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom
Texts:	1. Kuhn, M., & Johnson, K. (2013). Applied predictive modeling (Vol. 26, p. 13). New York: Springer. 2. De Prado, M. L. (2018). Advances in financial machine learning. John Wiley & Sons. 3. Reddy, C. K., & Aggarwal, C. C. (Eds.). (2015). Healthcare data analytics. CRC Press. 4. Artun, O., & Levin, D. (2015). Predictive marketing: Easy ways every marketer can use customer analytics and big data. John Wiley & Sons. 5. Zafarani, R., Abbasi, M. A., & Liu, H. (2014). Social media mining: an introduction. Cambridge University Press.
References/ Readings:	1. Klaas, J. (2019). Machine learning for finance: principles and practice for financial insiders. Packt Publishing Ltd. 2. Miller, T. W. (2015). Marketing data science: Modeling techniques in predictive analytics with R and Python. FT Press. 3. Shu, K., & Liu, H. (2022). Detecting fake news on social media. Springer Nature. 4. Hong, T. P., Serrano-Estrada, L., Saxena, A., & Biswas, A. (Eds.). (2022). Deep Learning for Social Media Data Analytics. Springer International Publishing.
Web Resources:	MIT course on Machine Learning for Healthcare. Retrieved on 28th May 2025, from: Machine Learning for Healthcare | Electrical Engineering and Computer Science | MIT OpenCourseWare

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Title of the Course	Data Security, Privacy, and Ethics
Course Code	CSD-5204
Number of Credits	4
Theory/Practical	Theory
Level	400
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To introduce foundational concepts of data privacy, ethics, and security, enabling students to responsibly manage and protect data in accordance with ethical principles and legal frameworks.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand fundamental concepts of data privacy, personal data, and ethical responsibility in data science.	PSO1, PSO2
	CO 2. Identify and evaluate ethical issues and privacy risks associated with data collection and usage.	PSO2, PSO3
	CO 3. Explain basic principles of data security and common types of security threats.	PSO1
	CO 4. Describe key data protection laws and compliance principles relevant to responsible data handling.	PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Module 1:	Introduction to Data Privacy: Definitions and significance, Personal vs. sensitive vs. anonymized data Personally Identifiable Information (PII): Identification and classification, Examples and consequences of misuse Data Lifecycle and Privacy Risks: Data collection, storage, processing, sharing, retention Ethical Foundations in Data Science: Ethical theories: Utilitarianism, Deontology, Virtue Ethics, Responsibilities of data scientists	**15**	CO1, CO2	K2, K3
Module 2:	Fair Information Practices (FIPs): Transparency, accountability, consent, purpose limitation Privacy by Design and Default: Core principles and relevance in data projects Ethical Dilemmas and Real-world Case Studies: Cambridge Analytica, Aadhaar, social media surveillance Bias, Discrimination, and Fairness in Data Systems: Data-driven bias, algorithmic transparency, fairness metrics (introductory level)	**15**	CO1, CO2	K2, K3
Module 3:	Introduction to Data Security CIA Triad: Confidentiality, Integrity, Availability Risk, threat, and vulnerability concepts Common Security Threats: Malware, phishing, ransomware (conceptual) Real-world examples of data breaches Basic Security Mechanisms: Passwords, authentication, and access control, Introductory concept of encryption and hashing.	**15**	CO3, CO4	K2,K3
Module 4:	Purpose of Data Protection Laws: Why laws are needed: protecting user rights and data responsibilities Key Legal Frameworks (Introductory) GDPR: Consent, data subject rights, accountability principles	**15**	CO3, CO4	K2,K3

	India's DPDP Act 2023: Applicability, personal data protection, user rights, HIPAA , Compliance and Ethical Responsibility, Basic role of a Data Protection Officer (DPO)			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments//Flipped classroom			
Texts:	Pfleeger, C. P., & Pfleeger, S. L. (2015). Security in computing (5th ed.). Pearson.			
References/ Readings:	1. Davis, K. (2012). Ethics of big data: Balancing risk and innovation. O'Reilly Media. 2. Stallings, W. (2021). Information privacy engineering and privacy by design. Pearson.			
Web Resources:	Government of India. (2023). The Digital Personal Data Protection Act, 2023 (No. 22 of 2023). The Gazette of India, Extraordinary, Part II, Section 1 (Gazette ID: CG-DL-E-12082023-248045). Retrieved October 7, 2025, from https://egazette.gov.in			

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SEMESTER III

Research Specific Elective (RSE) Courses

Title of the Course	Research Methodology
Course Code	CSD-6000
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	NIL	
Course Objectives:	To equip students with a comprehensive understanding of research principles, methodologies, and statistical tools, enabling them to formulate research problems, design experiments, analyze data, and effectively communicate results in a scholarly and ethical manner.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Analyze different types of research, research processes, and designs to critically distinguish between quantitative and qualitative approaches	PSO1, PSO3, PSO6
	CO 2. Apply systematic methods of problem formulation, hypothesis development, data	PSO1, PSO2,

	collection, and design of experiments to conduct research investigations.		PSO3, PSO6	
	CO 3. Evaluate research data using statistical methods such as hypothesis testing, regression, correlation, and ANOVA to draw valid conclusions.		PSO1, PSO2, PSO3, PSO5, PSO6	
	CO 4. Develop a research report or dissertation by incorporating ethical principles, proper referencing, and scientific writing practices.		PSO3, PSO5, PSO6, PSO7, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Introduction to research, Definitions and characteristics of research, Types of Research, Research Process, Problem definition, Objectives of Research, Research Questions, Research design, Quantitative vs. Qualitative Approach, Building and Validating Theoretical Models, Exploratory vs. Confirmatory Research, Experimental vs. Theoretical Research, Importance of reasoning in research.	**15**	CO1	K2, K3, K4
Unit 2:	Problem Formulation, Understanding Modeling & Simulation, Literature Review, Referencing, Information Sources, Information Retrieval, Indexing and abstracting services, Citation indexes, Development of Hypothesis, Measurement Systems Analysis, Error Propagation, Validity of experiments, Statistical Design of Experiments, Data/Variable Types & Classification, Data collection, Numerical and Graphical Data Analysis: Sampling, Observation, Interpretation of Results.	**15**	CO2	K2, K3
Unit 3:	Statistics: Probability & Sampling distribution, Estimation, Measures of central Tendency, Arithmetic mean, Median, Mode, Standard deviation, Co efficient of variation (Discrete serious and continuous serious), Hypothesis testing & application, Correlation & regression analysis, Orthogonal array, ANOVA, Standard error, Concept of point and interval estimation, Level of significance, Degree of freedom, Analysis of variance, One way and two way classified data, 'F' test.	**15**	CO3	K2, K3, K4, K5
Unit 4:	Preparation of Dissertation and Research Papers, Tables and illustrations, Guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript. References, Citation and listing system of documents. Introduction to LaTeX for scientific writing: Basics of LaTeX syntax and document structure, Creating academic documents using LaTeX, Formatting equations, tables, and	**15**	CO4	K2, K3, K4,K5, K6

	figures, Adding references using BibTeX and citation styles, Preparing dissertations, theses, and research papers in LaTeX Intellectual property rights (IPR) patents copyrights Trademarks Industrial design geographical indication. Ethics of Research Scientific Misconduct Forms of Scientific Misconduct. Plagiarism, Unscientific practices in thesis work, Ethics in science.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Bordens, K. S., & Abbott, B. B. (2002). *Research design and methods: A process approach*. McGraw-Hill. 2. Montgomery, D. C., & Runger, G. C. (2010). Applied statistics and probability for engineers. John wiley & sons. 3. Menell, P. S., Lemley, M. A., Merges, R. P., & Balganesh, S. (2023). Intellectual property in the new technological age: 2023. 4. Kottwitz, S. (2011). LaTeX beginner's guide. Packt Publishing Ltd.			
References/ Readings:	1. Kothari, C. R. (2004). *Research methodology: Methods and techniques*. New Age International. 2. Creswell, J. W. (2009). Research designs. Qualitative, quantitative, and mixed methods approaches. 3. Jackson, S. L. (2009). Research Methods and Statistics.			

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Title of the Course	Reinforcement Learning Techniques
Course Code	CSD-6001
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005			
Course Objectives:	To enable the student to understand core concepts of reinforcement learning.			
Course Outcomes:			**Mapped to PSO**	
	CO1. Understand the theoretical foundation of RL and its components.		PSO1	
	CO2. Compare model based and model free RL approaches.		PSO3, PSO4	
	CO3. Apply planning and learning methods reinforcement learning prediction.		PSO3, PSO4	
	CO4. Analyze on-policy and off-policy control methods with function approximation.		PSO3, PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	**Introduction**	**15**	CO1	K1, K2

	Background, Supervised, Unsupervised and Reinforcement Learning, RL framework, Limitations, Examples. **Multi-Arm Bandits** k-armed bandit problem, Exploration and Exploitation, Greedy, Epsilon greedy, Upper Confidence Bound, Gradient Bandit algorithms, Contextual Bandits. **Finite Markov Decision Processes** Agent, Environment, Goals, Rewards, Return, Episodic and Continuing tasks, Policies, Value functions, Optimal policies and value functions, Bellman Equations, Backup diagrams.			
Unit 2:	**Dynamic Programming** Policy evaluation, Policy improvement, Policy iteration, Value iteration, Asynchronous Dynamic Programming. **Monte Carlo Methods** Monte Carlo Prediction, Action value estimation, Control, Off-policy prediction, Off-policy control. **Temporal Difference Learning** TD Prediction, Advantages, On-policy TD control – SARSA, Off-policy TD control – Q learning, Expected SARSA, Maximization bias and double learning, n-step TD prediction, n-step SARSA, n-step off-policy learning.	**15**	CO2	K1, K2
Unit 3:	**Planning and Learning** Models, Dyna, Prioritized sweeping, Expected vs. Sample updates, Trajectory Sampling, Real time DP, Heuristic search, Rollout algorithms, Monte Carlo tree search. **On-policy Prediction with Approximation** Value function approximation, prediction objective, Stochastic-gradient and Semi-gradient Methods, Linear Methods, Non-linear function approximation, Memory based function approximation, Kernel based function approximation.	**15**	CO3	K1, K2, K3
Unit 4:	**On-policy Control with Approximation** Episodic Semi-gradient Control, Semi-gradient n-step Sarsa, Deprecating the	**15**	CO4	K1, K2, K3, K4

	Discounted Setting, Differential Semi-gradient n-step Sarsa. **Off-policy Methods with Approximation** Semi-gradient Methods, Off-policy Divergence, The Deadly Triad, Bellman Error, Gradient-TD Methods, Emphatic-TD Methods, Eligibility Traces. **Policy Gradient Methods** Policy Approximation, Advantages, Policy Gradient Theorem, REINFORCE, Actor–Critic Methods, Policy Parameterization.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	Sutton, R. S., & Barto, A. (2020). Reinforcement learning: An introduction (Second edition). The MIT Press.			
References/ Readings:	1. Szepesvári, C. (2022). Algorithms for reinforcement learning. Springer nature. 2. Lattimore, T., & Szepesvári, C. (2020). Bandit algorithms. Cambridge University Press. 3. Lapan, M. (2024). Deep Reinforcement Learning Hands-On. Packt Publishing Ltd.			
Web Resources:	1. DeepMind x UCL. (n.d.). Introduction to Reinforcement Learning. Google DeepMind. Retrieved September 22, 2025, from https://www.youtube.com/watch?v=TCCjZe0y4Qc 2. DeepMind x UCL. (n.d.). RL Course by David Silver. Google DeepMind. Retrieved September 22, 2025, from https://www.youtube.com/playlist?list=PLqYmG7hTraZDM-OYHWgPebj2MfCFzFObQ			

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Title of the Course	Deep Learning Models
Course Code	CSD-6002
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5001, CSD-5005	
Course Objectives:	To provide a comprehensive understanding of deep learning concepts, architectures, and applications.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand the historical development and foundational concepts of deep learning.	PSO1
	CO2. Compare advanced optimization and regularization techniques for training deep neural networks.	PSO3, PSO4
	CO3. Analyze and implement deep learning architectures such as convolutional networks for image modeling.	PSO3, PSO4
	CO4. Analyze advanced deep learning architectures for sequence modeling.	PSO3, PSO4

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	**Introduction** History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic Perceptrons, Perceptron Learning Algorithm, Multilayer Perceptrons, Representation Power of MLPs, Feedforward Neural Networks, Sigmoid Neurons, Gradient Descent, Backpropagation, Representation Power of Feedforward Neural Networks, Learning Vectorial Representations Of Words, Greedy Layerwise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization	**15**	CO1	K1, K2
Unit 2:	**Optimization for training Deep Models** Batch Gradient Descent (GD), Stochastic GD, Minibatch GD, Momentum Based GD, Nesterov Accelerated GD, AdaGrad, RMSProp, AdaDelta, Adam, Bias correction, Learning Rate Schedulers. **Regularization** Bias Variance Tradeoff, Train error vs Test error, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout	**15**	CO2	K1, K2, K3,K4
Unit 3:	**Convolutional Neural Networks** CNN, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks **Recurrent Neural Networks** RNN, Backpropagation Through Time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT	**15**	CO3	K1, K2, K3,K4
Unit 4:	**RNN Variants** Bidirectional RNNs, Gated Recurrent Units (GRUs), Long Short Term Memory (LSTM) Cells, Bidirectional Long Short Term Memory (BiLSTM), Solving the vanishing gradient problem with LSTMs	**15**	CO4	K1, K2, K3,K4

	Transformers Encoder Decoder Models, Attention Mechanism, Attention over images, Hierarchical Attention Transformers: Multi-headed Self Attention, Cross Attention			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press.			
References/ Readings:	1. Aggarwal, C. C. (2018). Neural networks and deep learning (Vol. 10, No. 978, p. 3). Cham: Springer. 2. Skansi, S. (2018). Introduction to Deep Learning: from logical calculus to artificial intelligence. Springer.			
Web Resources:	1. MIT OpenCourseWare. (n.d.). Introduction to Deep Learning. Massachusetts Institute of Technology. Retrieved September 22, 2025, from https://introtodeeplearning.com/ 2. OpenStax. (n.d.). Introduction to Deep Learning. OpenStax. Retrieved September 22, 2025, from https://openstax.org/books/principles-data-science/pages/7-3-introduction-to-deep-learning			

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Title of the Course	Regression Analysis and Predictive Model
Course Code	CSD-6003
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5001, CSD-5005	
Course Objectives:	To develop an understanding of regression analysis and model building.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand simple regression analysis.	PSO1
	CO2. Apply multiple regression techniques to perform hypothesis testing and model adequacy checks.	PSO2
	CO3. Explain transformation techniques and identify influential data points to enhance reliability of regression models.	PSO3
	CO4. Summarize multicollinearity issues in regression models and explore Generalized Linear Models.	PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	**Introduction** Regression analysis definition, Problem statement, Variable choice, Data collection, Model specification, Parameter estimation, Model fitting, Model evaluation, Applications. **Simple Regression Analysis** Linear and nonlinear models, Least square estimation, ordinary least squares estimation, Hypothesis testing, Interval estimation, Maximum likelihood estimation, Prediction.	**15**	CO1	K1, K2, K3
Unit 2:	**Multiple Regression Analysis** Overview, Estimation of model parameters, Hypothesis testing, Confidence intervals, inferences from multiple regression analysis, Prediction. **Model Adequacy Checking** Overview, Study and explanatory variables, Residual analysis, Scaling residuals, PRESS statistics, Outlier detection and treatment, Lack of fit.	**15**	CO2	K2, K3
Unit 3:	**Transformation techniques** Variance stabilizing transformations, Transformations to linearize the model, The Box-Cox method, transformations on the regressors variables, Generalized least squares, Weighted least squares. **Leverage and Influence** Significance, Leverage, Measures of influence, Cook's D-statistics, DFFITS and DFBETAS, Influential observations detection and treatment	**15**	CO3	K2, K3, K4, K5
Unit 4:	**Multicollinearity** Multicollinearity sources, Effects of multicollinearity, Multicollinearity diagnostics, Remedies for multicollinearity **Generalized Linear Models**	**15**	CO4	K2, K3

	Logistic Regression Models, Poisson Regression Models, link functions and linear predictors, parameter estimation and inference in the GLM, prediction and estimation with the GLM, Residual Analysis, and concept of over dispersion.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-projects			
Texts:	Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Introduction to linear regression analysis. John Wiley & Sons.			
References/ Readings:	1. Johnson, R A., Wichern, D. W., Applied Multivariate Statistical Analysis, Sixth Ed., PHI learning Pvt., Ltd., 2013. 2. Pardoe, I. (2020). Applied regression modeling. John Wiley & Sons.			
Web Resources:	Regression Analysis. Indian Institute of Technology Kanpur. Retrieved October 8, 2025, from https://home.iitk.ac.in/~shalab/course5.htm			

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Title of the Course	Data Engineering
Course Code	CSD-6004
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5000	
Course Objectives:	To provide students with a comprehensive understanding of the principles, tools, and techniques of data engineering.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand the fundamentals of data engineering.	PSO1
	CO2. Summarize data generation and storage process.	PSO1
	CO3. Explain data ingestion and transformation process.	PSO3
	CO4. Identify data serving techniques and security concerns.	PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	**Introduction** Definition, Data Engineering Lifecycle, Data Engineering Evolution, Data Engineering and Data Science, Data Engineering Skills and Activities, Data Maturity and the Data Engineer, Business responsibilities and Technical responsibilities of Data Engineer. **The Data Engineering Lifecycle** Components, The Data Lifecycle Versus the Data Engineering Lifecycle, Major Undercurrents Across the Data Engineering Lifecycle **Designing Good Data Architecture** Enterprise Architecture, Data Architecture, Principles of Good Data Architecture, Major Architecture Concepts, Types of Coupling, User Access, Event-Driven Architecture, Brownfield Versus Greenfield Projects.	**15**	CO1	K1, K2
Unit 2:	**Types of Data Architecture** Data Warehouse, Cloud Data Warehouse, Data Marts, Data Lake-Convergence, Next-Generation Data Lakes, and the Data Platform, Modern Data Stack, Lambda Architecture, Kappa Architecture, The Dataflow Model and Unified Batch and Streaming, Architecture for IoT, Data Mesh, Other Data Architectures. **Data Generation in Source Systems** Sources of Data, Source Systems, Files and Unstructured DataAPIs, Databases, Online Analytical Processing System, Types of Time-Source System, Data Sharing, Third-Party Data Sources, Message Queues and Event-Streaming Platforms, Impact of Undercurrents on Source Systems. **Storage** Components of Data Storage, Data Storage Systems, Data Engineering Storage	**15**	CO2	K1, K2, K3

	Abstractions, Trends in Storage			
Unit 3:	**Ingestion** Key Considerations, Bounded Versus Unbounded Data, Frequency, Synchronous Versus Asynchronous Ingestion, Serialization, Deserialization, Throughput, Scalability, Reliability, Durability, Payload, Push Versus Pull Versus Poll Patterns, Batch Ingestion, Message and Stream Ingestion, Ways to Ingest Data. **Queries, Modeling, and Transformation** Queries, The Query Optimizer, Improving Query Performance, Queries on Streaming Data, Data Models, Conceptual, Logical, and Physical Data Models, Normalization, Modeling Batch Analytical Data, Modeling Streaming Data, Transformations, Batch Transformations, Materialized Views, Federation, and Query Virtualization, Streaming Transformations and Processing	**15**	CO3	K1, K2, K3, K4, K5
Unit 4:	**Serving Data** General Considerations, Use Case, User, Data Products, Data Definitions and Logic, Data Mesh Analytics, Business Analytics, Operational Analytics, Embedded Analytics, Ways to Serve Data for Analytics and ML, File Exchange, Databases, Streaming Systems, Query Federation, Data Sharing, Semantic and Metrics Layers, Serving Data in Notebooks, Reverse ETL **Security and Privacy** People, Processes,Security Theater Versus Security Habit, Active Security, The Principle of Least Privilege, Shared Responsibility in the Cloud, Data Back Up, Patch and Update Systems, Encryption,Logging, Monitoring, and Alerting, Network Access, Security for Low-Level Data Engineering	**15**	CO4	K1, K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	Reis, J., & Housley, M. (2022) Fundamentals of Data Engineering.			
References/ Readings:	1. Kretz, A. (2019). The data engineering cookbook. Mastering the plumbing of data science. 2. Kleppmann, M. (2019). Designing data-intensive applications.			

	3. Macey, T. (2021). 97 Things Every Data Engineer Should Know. " O'Reilly Media, Inc.".
Web Resources:	Data Engineering Zoomcamp. (n.d.). Data Engineering Zoomcamp. DataTalksClub. Retrieved September 30, 2025, from https://github.com/DataTalksClub/data-engineering-zoomcamp?tab=readme-ov-file

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Title of the Course	Artificial Intelligence
Course Code	CSD-6005
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5001, CSD-5005	
Course Objectives:	To introduce the foundational concepts, techniques, and applications of Artificial Intelligence, enabling students to understand reasoning, learning, decision-making in intelligent agents.	
Course Outcomes:		**Mapped to PSO**
	CO1. Explain foundational concepts of Artificial Intelligence and implement problem-solving using search strategies	PSO1, PSO3
	CO2. Apply constraint satisfaction techniques and logical knowledge representation methods to solve AI problems.	PSO1, PSO3
	CO3. Analyze planning algorithms and probabilistic reasoning to handle uncertainty in AI systems.	PSO1, PSO3
	CO4. Explain decision-making frameworks and explainable AI methods to enhance	PSO7

	interpretability and transparency in AI systems.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	**Introduction to AI and Intelligent Agents** Definitions of AI, History and goals of AI, Overview of AI tribes (symbolic, connectionist, Bayesian, evolutionary, analogizer), Intelligent agents and environments, PEAS framework, Types of agents. **Problem-solving by searching** Problem formulation, Uninformed search strategies, Informed search strategies, Local search methods, Searching in continuous spaces, with non-deterministic actions, with partial observations, Online search agents, Adversarial search.	**15**	CO1	K1, K2, K3, K4, K5
Unit 2:	**Constraint Satisfaction Problems** Definition, Constraint Propagation, Backtracking Search for CSP, Local Search for CSP, Structure of CSP. **Knowledge Representation** Representations and mappings, Approaches, Issues, Knowledge based agents, Propositional logic, Agents based on propositional logic, Using First order logic, Knowledge engineering in first order logic, propositional vs first order inference, Unification and lifting, Forward chaining, Backward chaining, Resolution.	**15**	CO2	K1, K2, K3
Unit 3:	**Classical Planning** Algorithms for Planning, Planning Graphs, Analysis of Planning Approaches, Hierarchical Planning, Planning and Acting in Nondeterministic Domain, Multi-Agent Planning. **Probabilistic Reasoning** Bayesian networks, Representation of Conditional Distributions, Inference in Bayesian	**15**	CO3	K1, K2, K3, K4

	networks, Relational and First order probabilistic models,Applications of probabilistic reasoning.			
Unit 4:	**Decision-Making** Utility theory, Utility functions, Decision networks, Sequential Decision Problems, Markov Decision Processes (MDPs), Partially Observable MDPs, Decision with multiple agents. **Explainable AI** Background, Definitions, AI Black Box Problem, Need for Interpretability, XAI Methods and Classifications, Frameworks for Model Interpretability, Forms of Explanation, Evaluation methods, Challenges of XAI, Applications of XAI.	**15**	CO4	K1, K2, K3, K4. K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Russell, S. J., & Norvig, P. (2022). Artificial intelligence: A modern approach. (pp. I-XXVIII). Prentice hall.			
References/ Readings:	1. Aggarwal, C. C. (2021). Artificial intelligence: A textbook. Springer. 2. Wolfgang, E. (2017). Introduction to artificial intelligence. Springer. 3. Mehta, M., Palade, V., & Chatterjee, I. (Eds.). (2023). Explainable AI: Foundations, methodologies and applications (Vol. 232, p. 273). Springer. 4. Hsieh, W., Bi, Z., Jiang, C., Liu, J., Peng, B., Zhang, S., & Liang, C. X. (2024). A comprehensive guide to explainable ai: From classical models to llms. arXiv preprint arXiv:2412.00800.			
Web Resources:	MIT OpenCourseWare. (n.d.). Artificial Intelligence. Massachusetts Institute of Technology. Retrieved September 29, 2025, from https://ocw.mit.edu/courses/6-034-artificial-intelligence-fall-2010/			

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Title of the Course	Natural Language Processing
Course Code	CSD-6006
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005	
Course Objectives:	To introduce the foundations and deep learning approaches of Natural Language Processing, enabling students to understand language representations and apply core NLP techniques.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand the foundations of Natural Language Processing.	PSO1
	CO2. Apply shallow parsing and deep parsing techniques.	PSO3
	CO3. Analyze the architecture of deep learning models for NLP tasks.	PSO3
	CO4. Explain the application of transformer models in NLP tasks.	PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	**Introduction** Definition, Natural Language Understanding, Natural Language Generation, Three generations of NLP, NLP trinity, Corpora and their construction, concordance, collocation, regular expressions, Issues and Challenges, Performance evaluation. **Word Sense Disambiguation** Lexical knowledge networks, Princeton WordNet, Indian language wordnet, WordNet relations, WordNet applications, Idioms and Metaphors. **Computational Morphology** Definition, Agglutination, Types of morphology.	**15**	CO1	K1, K2, K3
Unit 2:	**Shallow Parsing** POS tagging, Chunking, Multi word expressions, Named entity recognition techniques, challenges and applications. **Deep parsing** Constituency parsing, Statistical parsing, Dependency parsing, Scope ambiguity, Attachment ambiguity, Rule Based parsing. **Sentiment Analysis** Ambiguity – lexical, syntactic, semantic, discourse, pragmatic, Lexicons – manual creation, automatic creation; Rule based – word level, sentence level, document level; Statistical – Naïve bayes, Support Vector Machine.	**15**	CO2	K1, K2, K3
Unit 3:	**Neural networks for NLP** Review of neural networks basics (Perceptron Feed forward networks, Back-propagation algorithm). **Word embeddings** Word2vec, Glove, FastText. **Deep Learning Models for NLP**	**15**	CO3	K1, K2, K3, K4

	Recurrent Neural Networks (RNN), Long Short-Term Memory (LSTM), Bidirectional Long Short-Term Memory (BiLSTM), Gated Recurrent Units (GRU), Text CNNs.			
Unit 4:	**Transformer Models** Background, Motivation; Encoder stack - input embedding, positional encoding, multihead attention, feedforward network; Decoder stack - output embedding, positional encoding, attention, linear layers. **Transformer v/s Humans** Human intelligence stack, Machine intelligence stack. **NLP applications and case-studies** Healthcare, E-commerce, Financial Services, Cybersecurity, Education	**15**	CO4	K1, K2, K3, K4, K5
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Bhattacharyya, P., Joshi, A., (2023). Natural Language Processing. Wiley India Pvt Ltd.			
References/ Readings:	1. Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning (Vol. 1, No. 2). Cambridge: MIT press. 2. Jurafsky, D., & Martin, J. H. (2008). Speech and language processing. Speech and Language Processing (2nd Edition)(Prentice Hall Series in Artificial Intelligence). 1. Tunstall, L., Von Werra, L., & Wolf, T. (2022). Natural language processing with transformers. " O'Reilly Media, Inc.". 2. Rothman, D. (2021). Transformers for Natural Language Processing: Build innovative deep neural network architectures for NLP with Python, PyTorch, TensorFlow, BERT, RoBERTa, and more. Packt Publishing Ltd			
Web Resources:	MIT OpenCourseWare. (n.d.). Advanced Natural Language Processing. Massachusetts Institute of Technology. Retrieved September 29, 2025, from https://ocw.mit.edu/courses/6-864-advanced-natural-language-processing-fall-2005/pages/lecture-notes/			

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Title of the Course	Applied Data Science in Agriculture
Course Code	CSD-6007
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005, CSD-5007, CSD-5011	
Course Objectives:	To enable students to apply data science techniques, machine learning models, and IoT for analyzing agricultural data and supporting data-driven decision-making in the Indian agricultural context.	
Course Outcomes:		**Mapped to PSO**
	CO1. Analyze the role of data science in Indian agriculture and identify challenges in agricultural data collection and preprocessing.	PSO1, PSO3, PSO6, PSO8
	CO2. Apply data science methods for soil health, crop monitoring, and yield prediction using real agricultural datasets.	PSO1, PSO2, PSO3, PSO4, PSO6, PSO8
	CO3. Analyze the applications of data science in livestock management and agricultural supply chains in Indian markets.	PSO1, PSO2, PSO3, PSO4, PSO5, PSO6, PSO8
	CO4. Apply IoT-based solutions for precision farming, irrigation, and livestock	PSO1, PSO2, PSO3, PSO4,

	monitoring in agriculture.		PSO5, PSO6, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Introduction to Data Science in Agriculture ● Importance of data in Indian agriculture ● Sources of agricultural data: IMD (weather), Soil Health Card, FASAL, ICAR, NDDB ● Challenges in agricultural data collection ● Basics of data preprocessing for agricultural datasets ● Case Study: Simple crop yield trend analysis using historical data	**15**	CO1	K2, K3, K4
Unit 2:	Data Science for Soil, Crop, and Weather Applications ● Soil health analysis: fertility mapping, nutrient status from soil health card data ● Crop monitoring: disease detection using image data, NDVI and remote sensing basics ● Weather data analytics: rainfall prediction, monsoon trend analysis ● Simple ML applications	**15**	CO2	K2, K3, K4
Unit 3:	Data Science in Livestock and Supply Chain ● Livestock data analytics: dairy yield, health monitoring, fodder requirement ● Supply chain issues in Indian agriculture: post-harvest losses, cold storage, transportation ● Market analytics: price forecasting for major crops ● Data visualization for agri-markets and supply chain decision-making ● Case Study	**15**	CO3	K2, K3, K4, K5
Unit 4:	IoT Applications in Agriculture	**15**	CO4	K2, K3

	• Sensor-based monitoring of crops: soil moisture, temperature, humidity • Smart irrigation: automated scheduling using IoT sensors • Livestock monitoring using wearable IoT devices • Real-time monitoring and decision support using IoT dashboards • Case Study			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Kumar, A., Verma, J. P., & Jain, R. (Eds.). (2025). Emerging Smart Agricultural Practices Using Artificial Intelligence. John Wiley & Sons. 2. Singh, R., Thakur, A. K., Gehlot, A., & Kaviti, A. K. (Eds.). (2022). Internet Of Things for Agriculture 4.0: Impact and challenges. CRC Press. 3. McKinney, W. (2012). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython. " O'Reilly Media, Inc.".			
References/ Readings:	1. Oliver, M. A., Bishop, T. F., & Marchant, B. P. (Eds.). (2013). Precision agriculture for sustainability and environmental protection (Vol. 39). Abingdon, UK: Routledge. 2. Lea, P. (2018). Internet of Things for Architects: Architecting IoT Solutions by Implementing Sensors, Communication Infrastructure, Edge Computing, Analytics, and Security. Germany: Packt Publishing. 3. Singh, R., Gehlot, A., Prajapat, M. K., & Singh, B. (2021). Artificial Intelligence in Agriculture. CRC Press. 4. Ahmad, L., & Nabi, F. (2021). Agriculture 5.0: Artificial Intelligence, IoT and Machine Learning. CRC Press. 5. Tomar, P., & Kaur, G. (Eds.). (2021). Artificial Intelligence and IoT-based Technologies for Sustainable Farming and Smart Agriculture. IGI Global. 6. Kose, U., Prasath, V. S., Mondal, M. R. H., Podder, P., & Bharati, S. (Eds.). (2022). Artificial Intelligence and Smart Agriculture Technology. CRC Press.			

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Title of the Course	Recommender System
Course Code	CSD-6008
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To provide a comprehensive understanding of recommender system concepts, techniques, and architectures, enabling students to design, develop, and evaluate effective recommendation models using collaborative, content-based, knowledge-based, and hybrid approaches.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand the fundamentals of recommender systems — including their functions, applications, and mathematical foundations using linear algebra.	PSO1
	CO2. Apply collaborative and content-based filtering techniques to design and implement personalized recommendation models.	PSO3
	CO3. Analyze and develop knowledge-based and hybrid recommendation approaches using reasoning, constraints, and multi-strategy designs.	PSO4

	CO4. Evaluate and enhance recommender systems through performance metrics, user-centered evaluation, and community-based recommendation methods.		PSO5	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	**Introduction to Recommender Systems** ● Functions and applications of recommender systems ● Linear algebra fundamentals: matrix addition, multiplication, transposition, inverses, and covariance matrices ● Understanding ratings and evaluation of recommendations ● Key issues and challenges in recommender systems	**15**	CO1	K2
Unit 2:	**Collaborative and Content-Based Filtering** ● Collaborative filtering: user-based and item-based nearest neighbor methods ● Model-based and preprocessing-based approaches ● Attacks on collaborative recommender systems ● Content-based recommendation: system architecture, item profiles, feature discovery, and user profile learning ● Similarity-based retrieval and classification algorithms ● Advantages and limitations of content-based filtering	**15**	CO2	K2, K3
Unit 3:	**Knowledge-Based and Hybrid Recommendation Approaches** ● Knowledge representation and reasoning ● Constraint-based and case-based recommenders ● Hybrid recommendation techniques ● Opportunities for hybridization and hybridization designs (monolithic, parallelized, pipelined) ● Limitations of hybridization strategies	**15**	CO3	K2, K3, K4
Unit 4:	**Valuation and Community-Based Recommender Systems**	**15**	CO4	K2, K3,

	• Evaluation of recommender systems: properties, designs, and datasets • Error, decision-support, and user-centered metrics • Recommender systems in social and collaborative environments • Communities and personalized web search • Social tagging, trust-based, and group recommender systems			K4
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Jannach D., Zanker M. and FelFering A., Recommender Systems: An Introduction, Cambridge University Press(2011), 1st ed.			
References/ Readings:	1. Ricci F., Rokach L., Shapira D., Kantor B.P., Recommender Systems Handbook, Springer(2011), 1st ed. 2. Manouselis N., Drachsler H., Verbert K., Duval E., Recommender Systems For Learning, Springer (2013), 1st ed.			

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Title of the Course	Sentiment Analysis
Course Code	CSD-6009
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5002, CSD-5003	
Course Objectives:	To equip students with theoretical knowledge and practical skills in sentiment analysis, including foundational Natural Language Processing techniques, machine learning approaches, lexicon-based methods, and advanced opinion mining tasks, enabling them to design and implement sentiment analysis solutions for real-world problems.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand sentiment analysis concepts, levels of analysis, and relevant Natural Language Processing challenges.	PSO1
	CO2. Apply supervised, unsupervised, and hybrid sentiment classification techniques to textual datasets.	PSO4
	CO3. Analyze aspect-based sentiment analysis systems and opinion summarization techniques.	PSO3

	CO4. Apply sentiment analysis models with respect to ethical, spam detection, and quality assessment issues.		PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Fundamental concepts Overview of sentiment analysis and opinion mining. Applications across domains. Levels of sentiment analysis. Sentiment lexicons and their issues. Natural Language Processing challenges for sentiment analysis. Opinion spam detection basics. Emerging trends and research challenges.	**15**	CO1	K1, K2
Unit 2:	Sentiment Classification Techniques Problem definitions in sentiment analysis. Opinion definition and sentiment analysis tasks. Document-level sentiment classification. Sentence subjectivity and sentiment classification.	**15**	CO2	K2, K3
Unit 3:	Aspect-based Sentiment Analysis & Opinion Summarization Aspect sentiment classification. Opinion compositional semantics. Aspect extraction techniques. Categorizing aspects. Entity, opinion holder and time extraction. Coreference resolution and word sense disambiguation. Sentiment lexicon generation. Opinion summarization techniques.	**15**	CO3	K2, K3, K4
Unit 4:	Advanced Topics and Ethical Considerations Comparative opinion analysis. Opinion search and retrieval. Opinion spam detection. Quality assessment of reviews. Ethics in sentiment analysis.	**15**	CO4	K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Liu, B. (2022). Sentiment analysis and opinion mining. Springer Nature.			
References/ Readings:	1. Liu, B. (2020). Sentiment analysis: Mining opinions, sentiments, and emotions (2nd Edition). Cambridge University. 2. Cambria, E., Das, D., Bandyopadhyay, S., & Feraco, A. (2017). A practical guide to sentiment analysis. Springer International Publishing.			

Web Resources:	1. Real Python. (2019, March 23). Sentiment analysis: First steps with Python's NLTK library. Retrieved October 7, 2025, from https://realpython.com/python-nltk-sentiment-analysis/ 2. JetBrains. (2024, December 12). Introduction to sentiment analysis in Python. Retrieved October 7, 2025, from https://blog.jetbrains.com/pycharm/2024/12/introduction-to-sentiment-analysis-in-python/

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Discipline Specific Vocational Elective (DSVE) Courses

Title of the Course	Software Engineering for Data-Driven Applications
Course Code	CSD-6401
Number of Credits	2T+2P
Theory/Practical	Theory & Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5003	
Course Objectives:	The objective of this course is to equip students with essential software engineering principles and practical skills tailored for data science projects. Students will learn to design, develop, test, and maintain robust software solutions, applying best practices for data-driven application development while ensuring scalability, efficiency, and ethical compliance.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand software engineering principles, design patterns, and architectures for data science applications.	PSO1
	CO2. Apply software development tools and practices to implement robust and scalable data science pipelines	PSO2

	CO3. Understand software modules for efficient integration of machine learning models into applications.		PSO4	
	CO4. Create software solutions following best practices and ethical standards for data science systems.		PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Introduction to Software Engineering in Data Science. Software development life cycle (SDLC) for data science projects. Design patterns and architectures for data-intensive applications. Requirements engineering for data science projects. Overview of Agile methodologies and DevOps in data science	**15**	CO1	K1, K2
Unit 2:	Practical Implementation of Data Science Software Pipelines ● Setting up software development environments for data science ● Version control with Git & GitHub ● CI/CD pipelines for data science workflows ● Integration of data sources and APIs ● Data ingestion, preprocessing, and pipeline automation ● Code testing and quality assurance for data applications	**30**	CO2	K2, K3
Unit 3:	Principles of designing AI-integrated software systems. Architectural considerations for deploying AI models. API design for model serving. Scalability and performance optimization in AI applications. Software documentation and maintainability	**15**	CO3	K1, K2
Unit 4:	Practical Deployment of AI-integrated Software Systems ● Deploying AI models using frameworks ● Containerization and orchestration (Docker, Kubernetes) ● Monitoring and maintaining deployed systems ● Ethical, privacy, and legal compliancies in deployment ● Security practices in software engineering for data science	**30**	CO4	K2, K3, K4, K5

Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom
Texts:	1. Pressman, R. S., & Maxim, B. R. (2020). Software Engineering: A Practitioner's Approach (9th ed.). McGraw-Hill Education. 2. Nelson, C. (2024). Software Engineering for Data Scientists.O'Reilly Media, Inc.
References/ Readings:	1. Humble, J., & Farley, D. (2011). Continuous delivery. Pearson Education. 2. Sommerville, I. (2016). Software Engineering (10th ed.). Pearson. 3. Huyen, C., & Zimmermann, T. (2022). Designing Machine Learning Systems. O'Reilly Media. 4. Skiena, S. S. (2017). The data science design manual. Springer. 5. Gold, A. (2024). DevOps for Data Science. Chapman and Hall/CRC.
Web Resources:	1. IEEE Computer Society. (n.d.). Software Engineering Body of Knowledge (SWEBOK). IEEE Computer Society. Retrieved October 7, 2025, from https://www.computer.org/swebok 2. Fowler, M. (2019). Microservices. Martin Fowler. Retrieved October 7, 2025, from https://martinfowler.com/microservices/ 3. Madison Hunter. (2021). Software engineering best practices for data science. Towards Data Science. Retrieved October 7, 2025, from https://towardsdatascience.com/software-engineering-best-practices-for-data-scientists-4c199ede6e03/ 4. Kubernetes. (n.d.). Kubernetes documentation. Kubernetes.io. Retrieved October 7, 2025, from https://kubernetes.io/docs/ 5. GitHub. (n.d.). GitHub documentation. GitHub. Retrieved October 7, 2025, from https://docs.github.com/en 6. ML Ops Community. (2022, June 8). Machine Learning Operations (MLOps) guide. Retrieved October 7, 2025, from https://ml-ops.org/ 7. Apache Airflow. (n.d.). Apache Airflow documentation. Apache Foundation. Retrieved October 7, 2025, from https://airflow.apache.org/docs/ 8. Tiangolo, S. (n.d.). FastAPI documentation. FastAPI. Retrieved October 7, 2025, from https://fastapi.tiangolo.com/ 9. TensorFlow. (n.d.). TensorFlow Serving guide. TensorFlow. Retrieved October 7, 2025, from https://www.tensorflow.org/tfx/guide/serving

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Title of the Course	Machine Learning Operations (MLOps)
Course Code	CSD-6402
Number of Credits	2T+2P
Theory/Practical	Theory & Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005, CSD-5009	
Course Objectives:	This course aims to equip students with foundational and advanced skills in Machine Learning Operations (MLOps), enabling them to design, deploy, monitor, and manage scalable ML systems using modern tools, cloud platforms, and best practices, while ensuring reliability, reproducibility, and ethical considerations.	
Course Outcomes:		**Mapped to PSO**
	CO1. Demonstrate foundational knowledge of MLOps by applying Linux, Python, cloud computing, and CI/CD concepts to design simple end-to-end ML workflows.	PSO1, PSO2, PSO3, PSO4, PSO5
	CO2. Apply advanced MLOps practices including containerization, edge deployment, AutoML, monitoring, interoperability, and ethical considerations to build scalable ML systems.	PSO1, PSO2, PSO3, PSO4, PSO5
	CO3. Create practical MLOps workflows by using Linux scripting, Python preprocessing, CI/CD pipelines, containerization, AutoML tools, logging, monitoring, and serverless	PSO1, PSO2, PSO3,

	deployment.		PSO4, PSO5, PSO8	
	CO4. Create integrated ML pipeline with model versioning, explainability, monitoring dashboards, and staged rollouts through a real-world mini-project.		PSO1, PSO2, PSO3, PSO4, PSO5, PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Foundations of MLOps ● Introduction to MLOps and the role of ML Engineer ● MLOps vs DevOps; DataOps concepts ● CI/CD for ML: GitHub Actions, automation pipelines ● Cloud computing basics for MLOps ● Linux/Bash essentials for ML workflows ● Python basics for MLOps, ML pipeline overview ● Building an end-to-end ML pipeline	**15**	CO1	K2, K3
Unit 2:	Advanced MLOps and Deployment ● Containers and containerized ML deployment ● Edge device integration for ML ● Model deployment, monitoring, and logging ● AutoML basics and feature stores ● Cloud-based MLOps: AWS / Azure pipelines ● Model interoperability: ONNX, Core ML ● Ethical considerations and case studies	**15**	CO2	K2, K3
Unit 3:	List of suggested Lab assignments 1. Linux and Cloud Basics: Practice Bash commands, file operations, and basic scripting to automate ML workflow tasks in Linux and cloud shell environments. 2. Python and Data Preprocessing: Write Python scripts to clean and preprocess a	**30**	CO3	K2, K3, K4, K5

	dataset, perform feature engineering, and exploratory data analysis. 3. CI/CD Pipeline for ML Models: Set up a GitHub repository for an ML project and implement CI using GitHub Actions to automate testing of ML code. 4. Containerization of ML Models: Dockerize a trained ML model and serve it over HTTP locally. 5. AutoML Experimentation: Train models using AutoML tools (FLAML, Google, AWS, or Azure) and compare with manually trained models. 6. Logging and Monitoring: Implement Python logging for model inference and monitor model performance using cloud monitoring tools. 7. Microservices / Serverless Deployment: Build a Flask API to serve ML predictions and deploy it as a serverless function using AWS Lambda or Azure Functions..			
Unit 4:	List of suggested Lab assignments 1. Design and implement a full ML workflow on Google Colab or Kaggle Kernels, including data loading, preprocessing, model training, and evaluation. 2. Maintain multiple versions of a model and deploy a selected version as a REST API using free tools like Streamlit, Flask, or FastAPI. 3. Use SHAP or LIME to analyze feature importance of a trained model and visualize prediction explanations. 4. Create a dashboard to track model metrics (accuracy, RMSE) over multiple runs using Plotly, Streamlit, or Google Sheets. 5. Simulate staged rollout of a new model version while monitoring its performance against the previous version. 6. Miniproject: Design and implement a complete ML solution that integrates data preprocessing, model training, explainability, deployment, monitoring, and controlled rollout. The project should simulate a real-world scenario where a dataset is collected, processed, and used to train an ML model, which is then deployed as an API or serverless function. The system should also include model versioning, performance tracking, and analysis of feature importance.	**30**	CO4	K2, K3, K4, K5

Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/miniproject
Texts:	1. Sweenor, D., Hillion, S., Rope, D., Kannabiran, D., Hill, T., & O'Connell, M. (2020). *ML Ops: Operationalizing Data Science*. O'Reilly Media, Incorporated. 2. Hapke, H., & Nelson, C. (2020). *Building machine learning pipelines*. O'Reilly Media.
References/ Readings:	1. Huyen, C. (2022). Designing machine learning systems. " O'Reilly Media, Inc.". 2. Gift, N., & Deza, A. (2021). *Practical MLOps*. " O'Reilly Media, Inc.". 3. Treveil, M., Omont, N., Stenac, C., Lefevre, K., Phan, D., Zentici, J., ... & Heidmann, L. (2020). *Introducing MLOps*. O'Reilly Media. 4. AlIa, S., & Adari, S. K. (2021). Beginning MLOps with MLFlow: Deploy Models in AWS Sage Maker Google Cloud and Microsoft Azure. *What Is MLOps?, Berkeley, CA, Apress*, 79-124.

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Title of the Course	Cloud-Based Big Data Solutions
Course Code	CSD-6403
Number of Credits	2T+2P
Theory/Practical	Theory & Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005, CSD-5009	
Course Objectives:	To equip students with theoretical understanding and practical skills for designing and implementing scalable big data solutions using open-source frameworks and cloud-inspired architectures.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply cloud computing principles to integrate and manage big data frameworks effectively.	PSO1, PSO3, PSO7
	CO 2. Apply knowledge of open-source tools to implement distributed data storage and processing.	PSO1, PSO2, PSO3, PSO5
	CO 3. Apply Hadoop and Spark to perform data storage and distributed processing in a simulated cloud environment.	PSO2, PSO4, PSO5, PSO6
	CO 4. Apply open-source tools to develop and automate an end-to-end big data analytics	PSO2, PSO3, PSO4,

	workflow.		PSO5, PSO7, PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Cloud and Big Data Foundations ● Overview of Cloud Computing: characteristics, service models, virtualization. ● Introduction to Big Data: definition, characteristics (3Vs, 5Vs), challenges. ● Distributed computing and storage fundamentals. ● Overview of open-source frameworks: Hadoop and Spark. ● Cloud-inspired architectures using open-source tools.	**15**	CO1	K2, K3
Unit 2:	Open-Source Tools for Big Data Analytics ● Hadoop ecosystem components: HDFS, MapReduce, YARN. ● Spark architecture and operations: RDDs, DataFrames, Spark SQL. ● Workflow management concepts and introduction to Apache Airflow. ● Designing data pipelines for storage and analytics. ● Case study: Building an open-source cloud-based big data solution.	**15**	CO2	K2, K3
Unit 3:	Big Data Environment Setup and Storage List of suggested lab assignments ● Installation and configuration of Hadoop (single-node). ● Working with HDFS for data ingestion and storage. ● Running sample MapReduce programs. ● Setting up Spark and executing PySpark programs (local/Colab). ● Implement a simple big data storage and retrieval pipeline using HDFS and Spark.	**30**	CO3	K2, K3
Unit 4:	Data Processing and Workflow Automation List of suggested lab assignments	**30**	CO4	K2, K3

	• Data analysis using Spark DataFrames and Spark SQL. • Automating workflows using Apache Airflow. • Visualizing Spark outputs using Python libraries (Matplotlib/Plotly). • Mini Project: Design and execute an end-to-end data processing and visualization pipeline using open-source tools.			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Rittinghouse, J. W., & Ransome, J. F. (2017). Cloud computing: implementation, management, and security. CRC press. 2. White, T. (2012). Hadoop: The definitive guide. " O'Reilly Media, Inc.". 3. Chambers, B., & Zaharia, M. (2018). Spark: The definitive guide: Big data processing made simple. " O'Reilly Media, Inc.".			
References/ Readings:	1. Erl, T., Puttini, R., & Mahmood, Z. (2013). Cloud computing: concepts, technology & architecture. Pearson Education. 2. Velte, A. T., Velte, T. J., Elsenpeter, R. C., & Elsenpeter, R. C. (2010). Cloud computing: a practical approach. 3. Marr, B. (2016). Big data in practice: how 45 successful companies used big data analytics to deliver extraordinary results. John Wiley & Sons.			
Web Resources:	1. Apache Software Foundation. (n.d.). *Apache Hadoop documentation (Version current)*. Apache Software Foundation. Retrieved October 7, 2025, from https://hadoop.apache.org/docs/current/ 2. Apache Software Foundation. (n.d.). *Apache Spark documentation (Version current)*. Apache Software Foundation. Retrieved October 7, 2025, from https://spark.apache.org/docs/ 3. Apache Software Foundation. (n.d.). *Apache Airflow documentation (Version current)*. Apache Software Foundation. Retrieved October 7, 2025, from https://airflow.apache.org/docs/			

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Title of the Course	Building Data-Driven Web and Mobile Applications
Course Code	CSD-6404
Number of Credits	2T+2P
Theory/Practical	Theory & Practical
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5003	
Course Objectives:	To equip students with the knowledge and practical skills to design, develop, and deploy responsive data-driven web and mobile applications. The course emphasizes integration with databases, APIs, and cloud platforms while applying modern software engineering principles and ethical considerations.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand foundational concepts of web and mobile application development and relevant frameworks.	PSO1
	CO2. Apply data-driven web applications using modern development frameworks and APIs.	PSO2
	CO3. Understand best practices for building secure, scalable, and maintainable mobile applications.	PSO3
	CO4. Apply secure, efficient, and ethically compliant mobile applications.	PSO7

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	Overview of web and mobile application architectures. Client-server model and REST APIs. Web development frameworks. Principles of responsive/inclusive design. Basics of UI/UX design. Security and Privacy in applications	**15**	CO1	K1, K2
Unit 2:	Practical Application Development (Web): List of suggested lab assignment ● Setting up development environments ● Building a responsive web application using a framework/stack ● Integrating APIs for dynamic content ● Connecting to databases ● Version control with Git ● Basic debugging and testing	**30**	CO2	K2, K3
Unit 3:	Mobile application platforms and frameworks. Mobile architecture and data integration. Working with APIs and cloud services. Mobile security and privacy considerations. Ethical issues in mobile app development. Offline functionality and data synchronization	**15**	CO3	K1, K2
Unit 4:	Practical Application Development (Mobile): List of suggested lab assignment ● Setting up a mobile development environment ● Building a mobile application using a chosen framework ● Integrating APIs and databases ● Implementing authentication and security features ● Deploying to app stores and/or cloud platforms	**30**	CO4	K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	1. Duckett, J. (2011). HTML and CSS: Design and Build Websites. Wiley. 2. Randhawa, T. S. (2022). Mobile Applications. Springer International Publishing.			

References/ Readings:	1. Flanagan, D. (2020). JavaScript: The Definitive Guide (7th ed.). O'Reilly Media. 2. Pilone, D., & Pilone, T. (2013). Head First IPhone and IPad Development. O'Reilly Media. 3. Ayaz, A. (2020). Hands-On App Development with Ionic. Packt Publishing.
Web Resources:	1. Mozilla Developer Network. (n.d.). Web development technologies. MDN Web Docs. Retrieved October 7, 2025, from https://developer.mozilla.org/en-US/docs/Learn 2. Google Developers. (n.d.). Firebase documentation. Google. Retrieved October 7, 2025, from https://firebase.google.com/docs 3. React. (n.d.). React documentation. Meta. Retrieved October 7, 2025, from https://react.dev/learn 4. Ionic Framework. (n.d.). Ionic documentation. Ionic Framework. Retrieved October 7, 2025, from https://ionicframework.com/docs 5. Apple Developer. (n.d.). SwiftUI documentation. Apple Inc. Retrieved October 7, 2025, from https://developer.apple.com/documentation/swiftui 6. Android Developers. (n.d.). Android app development guides. Google. Retrieved October 7, 2025, from https://developer.android.com/docs 7. W3Schools. (n.d.). JavaScript tutorial. W3Schools. Retrieved October 7, 2025, from https://www.w3schools.com/js/ 8. MDN Web Docs. (n.d.). REST APIs. Mozilla. Retrieved October 7, 2025, from https://developer.mozilla.org/en-US/docs/Glossary/REST 9. Microsoft Learn. (n.d.). Azure mobile app services. Microsoft. Retrieved October 7, 2025, from https://learn.microsoft.com/en-us/azure/app-service/ 10. Twilio. (n.d.). Twilio API documentation. Twilio. Retrieved October 7, 2025, from https://www.twilio.com/docs

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Generic Elective (GE) Courses

Title of the Course	Design Thinking for Data Intensive Applications
Course Code	CSD-6201
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with a comprehensive understanding of Design Thinking, enabling them to empathize with users, analyze problems, generate creative solutions, and iteratively prototype and test applications for real-world impact.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Understand the principles of Design Thinking and its application in everyday products and software development.	PSO3
	CO 2. Apply empathizing, analyzing, and problem-solving techniques to identify user needs and frame design challenges.	PSO3
	CO 3. Develop creative solutions through iterative ideation, prototyping, and concept	PSO4

	consolidation.			
	CO 4. Evaluate design solutions by testing with real users and incorporating feedback to refine and optimize outcomes.		PSO4	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	**Introduction and Empathize Phase (Iteration #1)** ● Introduction to Design Thinking: course outline, projects, and applications in software and everyday products ● Principles from *The Design of Everyday Things* ● Project management basics ● Empathize Phase: emotional and intellectual mapping, user story creation, and customer journey mapping	**15**	CO1	K2
Unit 2:	**Analyze and Solve Phase (Iteration #1)** ● Analyze Phase**:** identifying stated and latent needs, root cause analysis, multiple customer/manufacturer perspectives, framing conflicts ● Solve Phase**:** structured and unstructured creativity, group dynamics, brainstorming methods, inventive principles, concept creation and consolidation	**15**	CO2	K2, K3
Unit 3:	**Test Phase (Iteration #1) and Iteration #2** ● Test Phase (Iteration #1) / Empathize Phase (Iteration #2): basics of prototyping, assumptions, feature-focused concept validation ● Introduction to digital marketing, user experience design, and website development ● Analyze Phase (Iteration #2) and Solve Phase (Iteration #2): applying solutioning tools, ideation, testing, field trials, and analytical tools	**15**	CO3	K2, K3, K4
Unit 4:	**Iteration #3 and App Launch** ● Empathize Phase (Iteration #3): obtaining insights from live audience feedback ● Analyze Phase (Iteration #3): refining solutions based on feedback	**15**	CO4	K2, K3, K4, K5

	• Test Phase (Iteration #3): final testing, evaluation, and launch of the app			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Design of everyday things by Don A. Norman, 2013.			
References/ Readings:	This is Service Design thinking- basics, tools and cases by Marc Stickdorn, 1st edition,John Wiley & Sons Inc,2012.			

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Title of the Course	Designing Intelligent Agents
Course Code	CSD-6202
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	CSD-5005	
Course Objectives:	To enable the students to design cooperative and adaptive intelligent systems.	
Course Outcomes:		**Mapped to PSO**
	CO1. Analyze the evolution, structure, and architectures of intelligent agents.	PSO1, PSO3
	CO2. Evaluate foundational design patterns and prompt chaining techniques to design intelligent agents.	PSO1, PSO3
	CO3. Apply routing patterns, function calling mechanisms, and planning frameworks to design intelligent systems.	PSO1, PSO3
	CO4. Apply multi-agent collaboration strategies, learning and adaptation techniques, and existing agentic frameworks to enhance intelligent system.	PSO1, PSO3

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	**Introduction** Intelligent Agents, Definition, Historical evolution, Multi-agent systems, Agent communication languages **Intelligent Agent Architectures** Overview, The ReAct Model, Conceptual Layered Architecture, Perception, Cognition, Action, Reflection, Human-in-the-Loop Variants, Single Agent Architecture, Supervisor Agent Architecture, Hierarchical Agents Architecture, Agentic Network Architecture.	**15**	CO1	K1, K2, K3, K4
Unit 2:	**Foundational Design Patterns** Planning Pattern, Reflection Pattern, Tool Use Pattern, Multi-Agent Collaboration Pattern, Agent Adapter Pattern, Agent Evaluator, Goal Creator, Multi-modal Guardrails, Plan Generator, Retrieval Augmented Generation, Role-based Cooperation, Tool/Agent Registry, Vote-based Cooperation. **Prompt Chaining** Overview, Limitations of single prompts, Sequential Decomposition, Role of Structured Output, Context Engineering, Prompt Engineering, Practical Applications - Information Processing, Complex Query Answering, Data Extraction and Transformation, Content Generation, Code Generation, Multimodal and multi-step reasoning	**15**	CO1	K1, K2, K3, K4. K5
Unit 3:	**Routing Pattern** overview, LLM-based Routing, Embedding-based Routing, Rule-based Routing, ML Model-Based Routing, Parallelization Pattern, Reflection Pattern - Execution, Evaluation, Reflection, Iteration. **Function Calling** Tool Definition, LLM Decision, Function Call Generation, Tool Execution, Observation,	**15**	CO1	K1, K2, K3

	LLM Processing **Planning Pattern** Overview, Google Gemini DeepResearch, OpenAI Deep Research API			
Unit 4:	**Multi-Agent Collaboration** Sequential Handoffs, Parallel Processing, Debate and Consensus, Hierarchical Structures, Expert Teams, Critic-Reviewer, Exploring Interrelationships and Communication Structures **Learning and Adaptation** Reinforcement Learning, Supervised Learning, Unsupervised Learning, Few-Shot/Zero-Shot Learning, Online Learning, Memory-Based Learning, Proximal Policy Optimization, Direct Preference Optimization **Overview of Agentic Frameworks** LangChain, LangGraph, Google's ADK, Crew.AI, Microsoft AutoGen, LlamaIndex, MetaGPT, SuperAGI, Semantic Kernel, Strands Agents	**15**	CO1	K1, K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom/Mini-project			
Texts:	Gullí, A. (2025). Agentic design patterns: A hands-on guide to building intelligent systems. Springer Nature			
References/ Readings:	1. Horne, D. (2025) The Agentic AI Mindset–A Practitioner's Guide to Architectures, Patterns, and Future Directions for Autonomy and Automation. 2. Biswas, A., & Talukdar, W. (2025). Building Agentic AI Systems: Create intelligent, autonomous AI agents that can reason, plan, and adapt. Packt Publishing Ltd. 3. Russel, S., & Norvig, P. (2022). Artificial intelligence—a modern approach 3rd Edition. The Knowledge Engineering Review, 1, 78-79.			
Web Resources:	MIT OpenCourseWare. (n.d.). Artificial Intelligence. Massachusetts Institute of Technology. Retrieved September 29, 2025, from https://ocw.mit.edu/courses/6-034-artificial-intelligence-fall-2010/			

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Title of the Course	Social Media Analytics
Course Code	CSD-6203
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with essential knowledge of tools to collect, process, and analyze social media data for insights using Python and relevant libraries.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply Python and APIs (e.g., Twitter API) to collect and manage social media data for analysis.	PSO1, PSO2, PSO3
	CO 2. Apply preprocessing techniques to clean, transform, and explore social media datasets.	PSO2, PSO3, PSO5
	CO 3. Apply graph theory concepts, centrality measures, and community detection methods to construct and analyze social networks.	PSO1, PSO2, PSO3, PSO5
	CO 4. Apply NLP techniques and machine learning algorithms to perform sentiment analysis and trend detection for actionable insights.	PSO2, PSO3, PSO4, PSO5, PSO8

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	Introduction to Social Media Analytics ● Overview of social media platforms and data characteristics ● Basics of Python programming for data science (NumPy, Pandas) ● Introduction to APIs: REST APIs, OAuth authentication ● Working with Twitter API	**15**	CO1	K2, K3
Unit 2:	Data Preprocessing and Cleaning ● Data extraction and storage formats: JSON, CSV ● Text preprocessing techniques: Tokenization, stop-word removal, stemming, lemmatization ● Handling missing data and outliers using Pandas ● Exploratory data analysis (EDA) on social media data	**15**	CO2	K2, K3
Unit 3:	Social Network Analysis ● Introduction to graph theory and network analysis ● Building and visualizing social networks using NetworkX ● Centrality measures: Degree, closeness, betweenness ● Community detection algorithms: Girvan-Newman, Louvain	**15**	CO3	K2, K3
Unit 4:	Sentiment Analysis and Trend Prediction ● Sentiment analysis using Natural Language Toolkit (NLTK) and TextBlob ● Supervised machine learning algorithms (Logistic Regression, Naive Bayes) for classification ● Trend analysis and hashtag tracking ● Project: End-to-end analysis of social media data from extraction to visualization	**15**	CO4	K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			

Texts:	1. Liu, B. (2022). Sentiment analysis and opinion mining. Springer Nature. 2. Pozzi, F. A., Fersini, E., Messina, E., & Liu, B. (2016). Sentiment analysis in social networks. Morgan Kaufmann.
References/ Readings:	Russell, M. A. (2013). Mining the social web: data mining Facebook, Twitter, LinkedIn, Google+, GitHub, and more. " O'Reilly Media, Inc.".

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Title of the Course	Prompt Engineering Fundamentals
Course Code	CSD-6204
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To develop a foundational understanding of prompting techniques, large language models (LLMs), and vector databases, while building practical skills in text and image generation, autonomous agents, and AI-powered application development.	
Course Outcomes:		**Mapped to PSO**
	CO 1. Apply prompting principles and techniques to generate effective text.	PSO3
	CO 2. Apply large language models and LangChain to perform advanced AI tasks.	POS4
	CO 3. Apply vector databases and memory-enabled agents to develop AI solutions.	PSO4
	CO 4. Apply diffusion models to generate images and build end-to-end AI-powered applications.	PSO6

Content:		No of hours	Mapped to CO	Cognitive Level
Unit 1:	Foundations of Prompting and Language Models ● The Five Principles of Prompting: Overview, Give Direction, Specify Format, Provide Examples, Evaluate Quality, Divide Labor ● Introduction to Large Language Models (LLMs) for Text Generation: Text Generation Models, Vector Representations, Transformer Architecture, Probabilistic Text Generation, Historical Development, GPT Series, Google Gemini, Meta's Llama, Quantization, Mistral, Claude, GPT-4V, Model Comparison	**15**	CO1	K2, K3
Unit 2:	Text Generation Techniques and Practices ● Standard Practices for Text Generation with ChatGPT: List Generation, JSON and YAML, Invalid Payload Handling, Mock CSV, ELI5 Strategy, Universal Translation, Style Unbundling, Summarization, Chunking, Sentiment Analysis, Least to Most Technique, Role Prompting, Classification, Meta Prompting ● Advanced Text Generation with LangChain: Setup, Chat and Streaming Models, Prompt Templates, LCEL, Output Parsers, Function Calling, Data Extraction, Query Planning, Few-Shot Prompt Templates, Data Loading, Prompt Chaining, Document Chains	**15**	CO2	K2, K3
Unit 3:	Vector Databases and Autonomous Agents ● Vector Databases with FAISS and Pinecone: RAG, Embeddings, Document Loading, Memory Retrieval, Pinecone Usage, Self-Querying, Alternative Mechanisms ● Autonomous Agents with Memory and Tools: Chain-of-Thought, ReAct Agents, Tool Usage, LLMs as APIs, Custom Agents, Memory Management in LangChain, Advanced Agent Frameworks, Callbacks, Token Counting	**15**	CO3	K2, K3
Unit 4:	Image Generation and AI-Powered Application Development	**15**	CO4	K2, K3

	• Introduction to Diffusion Models for Image Generation: DALL-E, Midjourney, Stable Diffusion, Google Gemini, Text-to-Video Models, Model Comparison • Standard Practices for Image Generation with Midjourney: Format and Style Modifiers, Prompt Engineering, Inpainting, Outpainting, Consistent Characters, Meme Mapping • Advanced Techniques with Stable Diffusion: AUTOMATIC1111 Web UI, Img2Img, Upscaling, CLIP Interrogation, ControlNet, SAM, DreamBooth Fine-Tuning, Stable Diffusion XL Refiner • Building AI-Powered Applications: Blog Writing Process, Topic Research, Outline Generation, Text Generation, Title Optimization, Blog Image Generation, UI Design			
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Phoenix, J., & Taylor, M. (2024). Prompt Engineering for generative AI. " O'Reilly Media, Inc.".			
References/ Readings:	Negnevitsky, M. (2005). Artificial intelligence: a guide to intelligent systems. Pearson education.			

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Title of the Course	Rapid Application Development
Course Code	CSD-6205
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To equip students with the knowledge and practical skills to design, develop, and deploy rapid applications across web, mobile, and IoT domains using low-code and no-code platforms, enabling accelerated development cycles while maintaining usability and scalability.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand the principles and methodologies of Rapid Application Development, including low-code/no-code approaches.	PSO1
	CO2. Apply low-code/no-code platforms to develop dynamic web applications, integrating databases and APIs.	PSO2
	CO3. Apply mobile applications using no-code/low-code tools, integrating sensors, cloud services, and testing frameworks.	PSO3

	CO4. Understand IoT systems using no-code/low-code platforms, integrating sensors and automation tools to deploy functional smart applications.		PSO8	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	RAD principles and methodologies. Low-code vs. no-code development. Overview of web, mobile, and IoT applications. UI/UX principles for rapid development. Prototyping and wireframing tools.	**15**	CO1	K1, K2
Unit 2:	Static vs. dynamic websites. Database-driven web applications. Using platforms for web development. Integrating APIs and automation tools.	**15**	CO2	K2, K3
Unit 3:	Mobile app & development lifecycle. Using MIT App Inventor for mobile app development. Integrating mobile sensors and cloud services. Exporting and publishing mobile apps.	**15**	CO3	K2, K3
Unit 4:	IoT application & development lifecycle. Using platforms (like Tinkercad and Pictoblox) for IoT development. Integrating sensors and actuators. IoT app deployment considerations.	**15**	CO4	K1, K2
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Simon, P. (2022). Low-Code/No-Code: Citizen Developers and the Surprising Future of Business Applications. Wiley.			
References/ Readings:	1. Helzle, S. (2022). Low-Code Application Development with Appian. Packt Publishing. 2. Murru, E. (2020). Hands-On Low-Code Application Development with Salesforce. Packt Publishing. 3. Sabin-Wilson, L. (2024). WordPress All-in-one for Dummies. John Wiley & Sons. 4. Reynolds, M. (2021). No-Code AI and Machine Learning: Building AI Applications Without Coding. Apress. 5. Kamriani, F., & Roy, K. (2016). App Inventor 2 Essentials. Packt Publishing Ltd.			
Web Resources:	1. Creatio. (n.d.). The No-Code Playbook. Retrieved October 7, 2025, from https://www.creatio.com/sites/default/files/static-site/The-No-Code-Playbook.pdf 2. MIT App Inventor Documentation. (n.d.). Retrieved October 7, 2025, from https://appinventor.mit.edu/explore/library			

	3. Tinkercad Circuits. (n.d.). Retrieved October 7, 2025, from https://www.tinkercad.com/circuits 4. Bubble Manual. (n.d.). Retrieved October 7, 2025, from https://manual.bubble.io/ 5. STEMpedia. (n.d.). PictoBlox documentation: Get started with block coding, Python, AI projects & more. Retrieved October 7, 2025, from https://ai.thestempedia.com/docs/pictoblox/

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Title of the Course	Programming Paradigms
Course Code	CSD-6206
Number of Credits	4
Theory/Practical	Theory
Level	500
Effective from AY	2025-26
New Course	Yes
Bridge Course/ Value added Course	No
Course for advanced learners	No

Pre-requisites for the Course:	Nil	
Course Objectives:	To enable students to understand and apply various programming paradigms for developing efficient, modular, and scalable solutions in data science applications, by strengthening analytical reasoning and computational thinking.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand imperative programming concepts using procedural and object-oriented paradigms to solve computational problems.	PSO1
	CO2. Develop programs using functional and logic programming paradigms to enhance analytical reasoning and problem-solving skills.	PSO3
	CO3. create event-driven and parallel programming models to manage, process, and analyze large datasets efficiently.	PSO2
	CO4. Analyze multiple programming paradigms to develop innovative and scalable data	PSO6

	science applications.			
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Fundamental Concepts Concept, motivation, types and classification. Factors affecting programming languages Imperative Programming Concepts & Constructs. Procedural (in Python/C). Object Oriented (in Java/C++)	**15**	CO1	K2
Unit 2:	Functional Programming (in Haskell/Clojure/Scala) Mathematical functions. Side effects & Currying. Declare/define functions & composition. Recursion. Lazy evaluation. Lists. Higher order functions. Folds.	**15**	CO2	K3, K4, K5
Unit 3:	Logic Programming (in Prolog/ECLiPSe Constraint language) Mathematical logic. Logic programming with facts, rules and goals. Constraint logic programming. Constraints as relationships between variables. Solving puzzles. Event-driven Programming (in Python/.NET) Events, Handlers, Callback & Triggers. Scheduling. Reliable eventing. Asynchronous event.	**15**	CO3	K3, K4, K5
Unit 4:	Parallel Programming Shared programming (in OpenMP). Distributed programming (in MPI). CUDA. Multi-Paradigms Language support for multi paradigms. Reactive programming (in Elm/ReactiveX). Meta programming (in Lisp). Natural Language Programming (in SciLab/MATLAB)	**15**	CO4	K3, K4
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			

Texts:	1. Sebesta, R. W. (2019). Concepts of programming languages (12th ed.). Pearson. 2. Tucker, A., & Noonan, R. (2006). Programming languages: Principles and paradigms (2nd ed.). McGraw-Hill.
References/ Readings:	1. Abdennadher, S., & Frühwirth, T. (2003). Essentials of constraint programming. Springer. 2. MacLennan, B. J. (1999). Principles of programming languages: Design, evaluation, and implementation (3rd ed.). Oxford University Press.
Web Resources:	1. Haskell Community. (n.d.). Haskell documentation. Retrieved October 7, 2025, from https://www.haskell.org/documentation/ 2. SWI-Prolog. (n.d.). SWI-Prolog documentation / reference manual. Retrieved October 7, 2025, from https://www.swi-prolog.org/pldoc/index.html 3. Python Software Foundation. (n.d.). Documentation — Python.org. Retrieved October 7, 2025, from https://www.python.org/doc/ 4. Clojure. (n.d.). Clojure API documentation. Retrieved October 7, 2025, from https://clojure.org/api/api 5. Docs.scala-lang.org. (n.d.). Scala API docs. Retrieved October 7, 2025, from https://docs.scala-lang.org/api/all.html 6. NVIDIA. (n.d.). CUDA Toolkit Documentation 13.0. Retrieved October 7, 2025, from https://docs.nvidia.com/cuda/ 7. OpenMP Architecture Review Board. (n.d.). OpenMP Reference Guides / Specifications. Retrieved October 7, 2025, from https://www.openmp.org/resources/refguides/ 8. NERSC. (n.d.). Introduction to MPI. Retrieved October 7, 2025, from https://docs.nersc.gov/development/programming-models/mpi/ 9. Haskell.org. (n.d.). Documentation – Haskell. Retrieved October 7, 2025, from https://www.haskell.org/documentation/ 10. Elm. (n.d.). Documentation. Retrieved October 7, 2025, from https://elm-lang.org/docs 11. ReactiveX. (n.d.). ReactiveX — Documentation. Retrieved October 7, 2025, from https://reactivex.io/documentation 12. GNU Project. (n.d.). GNU Prolog manual. Retrieved October 7, 2025, from https://www.gprolog.org/manual/gprolog.html 13. Microsoft. (n.d.). .NET documentation — Microsoft Learn. Retrieved October 7, 2025, from

https://learn.microsoft.com/dotnet/

14. ECLiPSe. (n.d.). ECLiPSe documentation: user manual, constraint library manual, reference manual (Tutorials & API). Retrieved October 7, 2025, from https://eclipseclp.org/doc/
15. Oracle. (n.d.). The Java Tutorials & Java SE Documentation. Retrieved October 7, 2025, from https://docs.oracle.com/javase/

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Title of the Course	Web Data Analytics	
Course Code	CSD-6207	
Number of Credits	4	
Theory/Practical	Theory	
Level	500	
Effective from AY	2025-26	
New Course	Yes	
Bridge Course/ Value added Course	No	
Course for advanced learners	No	
Pre-requisites for the Course:	Nil	
Course Objectives:	This course aims to equip students with a deep understanding of web data analytics, integrating theoretical concepts, advanced tools, and real-world applications. Students will learn to collect, process, analyze, and visualize web-generated datasets, apply modern analytical frameworks including AI-enabled analytics, and derive actionable insights to solve complex problems in a data-driven environment.	
Course Outcomes:		**Mapped to PSO**
	CO1. Understand fundamental concepts and technologies of web data analytics, including architecture and data sources.	PSO1
	CO2. Apply skills in collecting, processing, and managing web data using modern tools and techniques.	PSO2
	CO3. Analyze web data using advanced metrics, models, and visualization techniques.	PSO3

	CO4. Apply ethical, competitive, and performance analysis principles using advanced web analytics tools and AI-driven analytics platforms.		PSO7	
Content:		**No of hours**	**Mapped to CO**	**Cognitive Level**
Unit 1:	Introduction to Web Data Analytics. Web ecosystem & architecture: Client/Server, HTTP, TCP/IP, server logs. Web analytics process and lifecycle. Data sources: offsite & onsite analytics. Web analytics platforms and tools overview. Web privacy and security fundamentals. Emerging trends in Web Analytics (AI-enabled analytics).	**15**	CO1	K1, K2
Unit 2:	Data collection techniques: clickstream, outcome data, research data, competitive data. Data capture methods: web logs, javascript tagging, APIs. Data cleaning, preprocessing, and transformation. Heuristic evaluations, usability testing. Survey design and analysis (post-visit and website surveys). Legal, privacy, and ethical concerns in data collection. Emerging tools for automated web data collection.	**15**	CO2	K2, K3
Unit 3:	Data capture vs. data serve. Link coding and session tracking. Key web metrics: page views, hits, unique visitors, bounce rate, conversion rate, dwell time, etc. KPI development for different web objectives. Data modeling for web analytics: segmentation, cohort analysis, funnel analysis. Visualization techniques for web metrics. Dashboard design and storytelling with data. Introduction to AI-driven analytics and predictive modeling for web data.	**15**	CO3	K3, K4
Unit 4:	Web Analytics 1.0 vs 2.0 vs 3.0 (AI and IoT integration). Competitive intelligence in web analytics. Google Analytics 4 and advanced features. Search Engine Optimization (SEO) analytics. Paid vs organic traffic analysis. Google Ads integration and performance optimization. Benchmarking and performance comparison. Privacy, ethics, and legal compliance in advanced analytics. Emerging trends: real-time analytics, personalization, behavioral analytics.	**15**	CO4	K2, K3
Pedagogy:	Lectures/ Tutorials/Hands-on assignments/Flipped classroom			
Texts:	Kaushik, A. (2009). Web analytics 2.0: The art of online accountability and science of customer centricity. Wiley.			
References/	1. Clifton, B. (2012). Advanced web metrics with Google Analytics (3rd ed.). Wiley.			

Readings:	2. Sterne, J. (2003). Web metrics: Proven methods for measuring web site success. Wiley.
Web Resources:	1. Google Analytics Help Center. (n.d.). Google Analytics. Retrieved October 7, 2025, from https://support.google.com/analytics 2. Google Analytics for Beginners. (n.d.). Analytics Academy. Retrieved October 7, 2025, from https://analytics.google.com/analytics/academy/course/6 3. Google Tag Manager Help Center. (n.d.). Google Tag Manager. Retrieved October 7, 2025, from https://support.google.com/tagmanager 4. Google Data Studio Help Center. (n.d.). Google Data Studio. Retrieved October 7, 2025, from https://support.google.com/datastudio 5. Open Web Analytics. (n.d.). Open Web Analytics. Retrieved Oct 7, 2025, from https://www.openwebanalytics.com

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