| Effective from Session: 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT523 | **Title of the Course** | Statistical Machine Learning II | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | III | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objective is to learn the basic concept Statistical Learning | | | | | | |

| Course Outcomes | |
|---|---|
| **CO1** | Summarize multivariate data using numerical and graphical tools, detect outliers, measure multivariate distances, and reduce data complexity using PCA, EFA, and MDS. |
| **CO2** | Apply discriminant analysis (LDA, QDA, logistic regression, Bayes), and perform clustering using similarity measures, hierarchical (Ward's) and non-hierarchical (K-means) methods, and perceptual mapping. |
| **CO3** | Interpret population and sample principal components, use biplots, apply orthogonal factor models, and estimate factor loadings and scores for dimension reduction. |
| **CO4** | Understand Bayesian inference for single/multi-parameter models, hierarchical models, and perform model checking, posterior predictive analysis, and model comparison |
| **CO5** | Use Bayesian computation (MCMC, Gibbs, Metropolis, HMC, STAN), and apply Bayesian regression with single/multiple predictors, hierarchical and generalized linear models. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Multivariate Data Analysis** | Multivariate data and its summaries (numeric and graphical), detection of outliers, making inferences from multivariate data, use of multivariate distance measures, reducing data complexity through Principal Component Analysis (PCA), Exploratory Factor Analysis (EFA), and basics of Multidimensional Scaling (MDS). | 08 | 1 |
| 2 | **Classification and Clustering Techniques** | Discriminant analysis using distance measures, assessing normality and data transformations, classification using Bayes theorem, linear and quadratic discriminant analysis (LDA & QDA), stepwise discriminant function analysis, canonical discriminant functions, logistic regression; introduction to clustering methods including similarity measures, hierarchical clustering (including Ward's method), non-hierarchical clustering (K-means), statistical model-based clustering, multidimensional scaling, correspondence analysis, and perceptual mapping. | 08 | 2 |
| 3 | **Principal Components and Factor Analysis** | Principal components for population and sample data, uses and applications of PCA, inference in large samples, graphical representation through biplots, orthogonal factor models for dimension reduction, estimation and interpretation of factor loadings and factor scores, and their role in understanding multivariate structure. | 08 | 3 |
| 4 | **Fundamentals of Bayesian Inference and Analysis** | Fundamentals of Bayesian inference including probability foundations, inference for single and multi-parameter models, asymptotic behavior and links with frequentist methods, introduction to hierarchical models; Bayesian data analysis involving model checking, posterior predictive checking (including graphical diagnostics), model evaluation and comparison using information criteria, cross-validation, and approaches to model expansion. | 08 | 4 |
| 5 | **Bayesian Computation and Regression Models** | Bayesian computation methods including MCMC simulations, Gibbs sampler, Metropolis and Metropolis-Hastings algorithms, diagnosing convergence, effective number of simulation draws, Hamiltonian Monte Carlo methods, and implementation using STAN; Bayesian regression models for single and multiple predictors, hierarchical linear models, and generalized linear models under the Bayesian framework. | 08 | 5 |

| Reference Books: |
|---|
| Gelman, A., John B. Carlin, Hal S. Stern, David B. Dunson, Aki Vehtari and Donald B. Rubin (2014): Bayesian Data Analysis. 3rd Edition. Chapman and Hill. |
| Peter, D. H. (2009): A First Course in Bayesian Statistical Methods. Springer-Verlag. New York |
| Rao, C. R. and Rao, M. M., Multivariate Statistics and Probability, 2014, Elsevier & Academic Press. |
| Richard A. Johnson and Dean W. Wichern, Applied Multivariate Statistical Analysis, 2017, 7th Edition, Prentice Hall India. |
| **e-Learning Source:** |
| https://www.youtube.com/watch?v=Os1iqgpelPw |

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

# *Justification for CO-PO-PSO Mapping*

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT523 | **Title of the Course** | Statistical Machine Learning-II | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |

**CO1**: **Summarize multivariate data using numerical and graphical tools, detect outliers, measure multivariate distances, and reduce data complexity using PCA, EFA, and MDS.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology. (Mapped as 2-Moderate)

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**CO2: Apply discriminant analysis (LDA, QDA, logistic regression, Bayes), and perform clustering using similarity measures, hierarchical (Ward's) and non-hierarchical (K-means) methods, and perceptual mapping**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology. (Mapped as 2-Moderate)

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**CO3:** Interpret population and sample principal components, use biplots, apply orthogonal factor models, and estimate factor loadings and scores for dimension reduction.

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology. (Mapped as 2-Moderate)

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**CO4:** Understand Bayesian inference for single/multi-parameter models, hierarchical models, and perform model checking, posterior predictive analysis, and model comparison.

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped- 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology. (Mapped as 3-High)

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**CO5 Use Bayesian computation (MCMC, Gibbs, Metropolis, HMC, STAN), and apply Bayesian regression with single/multiple predictors, hierarchical and generalized linear models.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology. (Mapped as 2-Moderate)

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT556 | **Title of the Course** | Optimization Techniques for Data Science | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | III | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | To introduce optimization techniques including linear programming, transportation, assignment, and game theory models. The course also covers job scheduling, replacement models, and inventory management with a focus on solution methods and cost analysis. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Formulate and solve linear programming problem using different methods. |
| **CO2** | Solve transportation and assignment problems using different methods, and its variations. |
| **CO3** | Apply game theory concepts and decision-making techniques using dominance principle, graphical methods. |
| **CO4** | Analyze scheduling and replacement models for job sequencing and item deterioration/failure analysis. |
| **CO5** | Design and apply inventory models to optimize costs, EOQ, and single-period probabilistic inventory decisions. |

| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| 1 | **Linear Programming Problem** | Introduction Linear programming problem (LPP), Mathematical formulation of the problem, Graphical solution method, Canonical and standard forms of linear programming problem, the computational procedure of simplex method, Big-M method, Formulating dual problem. | 08 | 1 |
| 3 | **Transportation & Assignment Problem** | Introduction, Existence of solution in transportation problem, Solution of a transportation problem, Various method of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem, assignment problem, Mathematical formulation of the problem, Solution method of assignment problem using Hungarian method and Variations in assignment problem. | 08 | 2 |
| 5 | **Game Theory** | Basic definitions, Two-person Zero-sum games, Some basic terms, The maximin-minimax principle, Games without saddle point, Graphical solution of 2 × n and m × 2 games, Dominance property, General solution of m × n rectangular games. | 08 | 3 |
| 7 | **Sequencing & Replacement Problems** | Basic assumptions, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines. Replacement of items that deteriorate with time, Replacement of items that fails suddenly. | 08 | 4 |
| 8 | **Inventory Models** | Types of inventory models, Various costs associated with inventories, Deterministic inventory models, The concept of economic order quantity, Single period probabilistic inventory models | 08 | 5 |

**Reference Books:**


1 H.A. TAHA "Operations Research- An Introduction" Pearson.

2. K.Swarup, P.K.Gupta and A. Manmohan, "Operations Research", S. Chand

3. Hiller and Lieberman, "Introduction to Operations Research", Mc Graw Hill Company.

4. J.K.Sharma, "Operations Research ", Pearson.


**e-Learning Source:**

https://www.youtube.com/watch?v=a2QgdDk4Xjw

https://www.youtube.com/results?search_query=sequencing+and+replacement+problems+br+nptel

https://www.youtube.com/watch?v=OKHiS0xDBb4&list=PLDlJ2nw7-dHb3oowMJfwgleor6dwWsVZ1

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | - | - | - | - | - | 2 | 2 | 3 | 2 | 3 | 3 |
| **CO2** | 3 | - | - | - | - | - | 2 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 2 | - | - | - | - | - | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 2 | 3 | 2 | 3 | 2 | 2 |
| **CO5** | 2 | - | - | - | - | - | 2 | 2 | 3 | 2 | 3 | 3 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

# *Justification for CO-PO-PSO Mapping*

| Effective from Session: 2025-26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | **MT556** | **Title of the Course** | Optimization Techniques for Data Science | **L** | **T** | **P** | **C** |
| **Year** | **II** | **Semester** | **III** | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | **None** | **Co-requisite** | **None** | | | | |

**CO1: Formulate and solve linear programming problem using different methods.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2 - High).
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2 - High).
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 2 - High).
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3 - High).
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 2 - Moderate).
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3 - Moderate).
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3 - Moderate).

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**CO2: Solve transportation and assignment problems using different methods, and its variations.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3 - Moderate).
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2 - High).
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 3 - High).
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 2 - High).
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3 - Moderate).
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 2 - Moderate).
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3 - Moderate).

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**CO3: Apply game theory concepts and decision-making techniques using dominance principle, graphical methods.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems **(Mapped as 2- High).**
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3 - High).
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 3- High).
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3 - High).
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 2 - Moderate).
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3 - Moderate).
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2 - Moderate).

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**CO4: Analyze scheduling and replacement models for job sequencing and item deterioration/failure analysis.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3 - Moderate).
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3 - High).
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 3 - High).
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 2 - High).
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3 - Moderate).
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 2 - Moderate).
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2 - Moderate).

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**CO5: Design and apply inventory models to optimize costs, EOQ, and single-period probabilistic inventory decisions.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2- High).
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2 - High).
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 2 - High).
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3 - High).
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3 - Moderate).
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3 - Moderate).
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2 - Moderate).

| Effective from Session: 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | CS569 | **Title of the Course** | Neural Network Analysis | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | III | 3 | 1 | 0 | 4 |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | Understand the fundamentals of neural networks and their mathematical foundations<br>Learn to implement and optimize deep neural network architectures<br>Analyze and apply convolutional neural networks for image-related tasks<br>Model sequential and time-series data using recurrent neural networks and variants<br>Explore advanced neural models like autoencoders, GANs, and transformers<br>Apply model evaluation techniques and perform hyperparameter tuning effectively | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Gain foundational understanding of neural networks, including perceptrons, activation functions, and backpropagation. |
| **CO2** | Develop skills to build, train, and optimize deep neural networks using various algorithms and tuning techniques. |
| **CO3** | Apply convolutional neural networks for image recognition and classification using real-world datasets. |
| **CO4** | Model and analyze sequential data using RNNs, LSTMs, and GRUs for time-series and language tasks |
| **CO5** | Explore advanced architectures like GANs and transformers, and evaluate neural models for fairness. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Fundamentals of Neural Networks** | Biological vs Artificial Neurons, Perceptron, Multilayer Perceptron (MLP), Activation Functions (ReLU, Leaky ReLU, Softmax), Forward Propagation, Cost Functions, Gradient Descent, Backpropagation Algorithm, Overfitting, Regularization (L1, L2, Dropout) | 8 | 1 |
| 2 | **Deep Learning and Optimization** | Deep Neural Networks, Data Augmentation, Optimization Algorithms (SGD, Momentum, RMSProp, Adam), Vanishing Gradient Problem, Exploding Gradient Problem | 8 | 2 |
| 3 | **Convolutional Neural Networks (CNNs)** | Convolution Operation, Filters and Feature Maps, Pooling Layers, CNN Architectures (LeNet, AlexNet, VGG, ResNet), Transfer Learning. | 8 | 3 |
| 4 | **Recurrent Neural Networks and Sequence Modeling** | RNN, LSTM, GRU, Bidirectional RNNs, Sequence-to-Sequence Models, Text Generation, Sentiment Analysis, Time-Series Prediction. | 8 | 4 |
| 5 | **Advanced Topics and Interpretability** | Attention Mechanism, Transformers (Basic Overview), Autoencoders, Variational Autoencoders (VAE), Generative Adversarial Networks (GANs). | 8 | 5 |

**Reference Books:**


**Deep Learning** by Ian Goodfellow, Yoshua Bengio, and Aaron Courville – *MIT Press*

**Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow** by Aurélien Géron – *O'Reilly Media*

**Neural Networks and Deep Learning** by Michael Nielsen– *(Online open-access book)*

**Pattern Recognition and Machine Learning** by Christopher M. Bishop – *Springer*


**e-Learning Source:**

| | **Course Articulation Matrix: (Mapping of COs with POs and PSOs)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO- PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | 3 | | | 1 | | | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | | | | |
| **CO3** | 2 | | 2 | | | | | 2 | 3 | | 3 | 3 |
| **CO4** | 2 | 2 | | | | 2 | | | | 3 | 2 | |
| **CO5** | 3 | 2 | 3 | 2 | 3 | | | 3 | 2 | 3 | 2 | 3 |

**1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

| Effective from Session: 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | **CS609** | **Title of the Course** | **Big Data Engineering** | **L** | **T** | **P** | **C** |
| **Year** | **II** | **Semester** | **III** | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | **None** | **Co-requisite** | **None** | | | | |
| **Course Objectives** | To study the basic technologies that forms the foundations of Big Data.<br>To study the programming aspects of cloud computing with a view to rapid prototyping of complex applications.<br>To understand the specialized aspects of big data including big data application, and big data analytics.<br>To study different types Case studies on the current research and applications of the Hadoop and big data in industry. | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Student must be Able to understand the building blocks of Big Data. |
| **CO2** | Student must be able to articulate the programming aspects of cloud computing(map Reduce etc.) |
| **CO3** | Student must be able to understand the specialized aspects of big data with the help of different big data applications |
| **CO4** | Student must be able to represent the analytical aspects of Big Data. |
| **CO5** | Student must be know the recent research trends related to Hadoop File System, MapReduce and Google File System etc. |

| **Unit No.** | **Title of the Unit** | **Content of Unit** | **Contact Hrs.** | **Mapped CO** |
|---|---|---|---|---|
| 1 | **Data structures in Java** | Data structures in Java: Linked List, Stacks, Queues, Sets, Maps; Generics: Generic classes and Type parameters, Implementing Generic Types, Generic Methods, Wrapper Classes, Concept of Serialization | 8 | 1 |
| 2 | **Working with Big Data** | Google File System, Hadoop Distributed File System (HDFS) – Building blocks of Hadoop (Namenode, Datanode, Secondary Namenode, Job Tracker, Task Tracker), Introducing and Configuring Hadoop cluster (Local, Pseudo-distributed mode, Fully Distributed mode), Configuring XML files | 8 | 2 |
| 3 | **Writing MapReduce Programs** | Understanding Hadoop API for MapReduce Framework, Basic programs of Hadoop MapReduce: Driver code, Mapper code, Reducer code, Record Reader, Combiner, Partitioner | 8 | 3 |
| 4 | **Hadoop I/O** | The Writable Interface, Writable Comparable and comparators, Writable Classes: Writablewrappers for Java primitives, Text, Bytes Writable, Null Writable, Object Writable and Generic Writable, Writable collections, Implementing a Custom Writable: Implementing a Raw Comparator for speed, Custom comparators | 8 | 4 |
| 5 | **Pig and hive** | Pig Architecture, Evaluating Local and Distributed Modes of Running Pig Scripts, Checking out the Pig Script Interfaces. Hadoop Data with Hive: Saying Hello to Hive, Seeing How the Hive is Put Together, Getting Started with Apache Hive, Examining the Hive Clients, Working with Hive Data Types, Creating and Managing Databases and Tables, Seeing How the Hive Data Manipulation Language Works, Querying and Analyzing Data. | 8 | 5 |

**Reference Books:**


Big Java 4th Edition, Cay Horstmann, Wiley John Wiley & Sons, INC

Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'reilly, Hadoop in Action by Chuck Lam, MANNING Publ.

Hadoop: The Definitive Guide by Tom White, 3rd Edition, O'reilly Hadoop for Dummies by Dirk deRoos, Paul C.Zikopoulos, Roman B.Melnyk,Bruce Brown, Rafael Coss


**e-Learning Source:**

**https://nptel.ac.in/courses/106104189**

| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 1 | 1 | – | – | – | – | – | – | – | – | 2 | 2 |
| **CO3** | 2 | 2 | 1 | 2 | 1 | – | – | – | – | – | – | – | – | 2 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 1 | – | – | – | – | – | – | – | – | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 3 | 2 | – | – | – | – | – | – | – | – | 2 | 2 |

**1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |
|---|---|

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT560 | **Title of the Course** | Structured Query Language | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objective is to learn the basic concept SQL | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Understand relational database concepts and apply foundational SQL commands for data creation and retrieval. |
| **CO2** | Write queries to filter, sort, aggregate, and group data for analysis using SQL. |
| **CO3** | Perform complex data operations involving multiple tables, joins, subqueries, and set operations. |
| **CO4** | Utilize advanced SQL features such as window functions, CTEs, and transactions for data manipulation and performance optimization. |
| **CO5** | Apply SQL in real-world data science scenarios including data cleaning, analysis, and reporting using BI tools and capstone projects. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Introduction to Databases and SQL Basics** | Overview of databases and their types (Relational vs Non-relational); Introduction to RDBMS (MySQL, PostgreSQL); SQL vs NoSQL (focus on relational); SQL syntax, data types; database objects – tables, views, indexes; creating/modifying tables; data insertion; basic SELECT queries. | 08 | 1 |
| 2 | **Data Retrieval, Filtering, and Aggregation** | Retrieving data with SELECT, WHERE, ORDER BY, DISTINCT; logical and comparison operators (AND, OR, NOT, =, <>, IN, BETWEEN, LIKE); handling NULLs, using LIMIT, OFFSET, aliases; aggregate functions (COUNT, SUM, AVG, etc.); GROUP BY, HAVING, nested aggregations; case study on sales data. | 08 | 2 |
| 3 | **Working with Multiple Tables and Data Manipulation** | JOINs (INNER, LEFT, RIGHT, FULL); self-joins, aliasing, UNION, INTERSECT, EXCEPT; subqueries – scalar, correlated, derived; real-world joins (e.g., customer-orders); INSERT, UPDATE, DELETE; transaction control (COMMIT, ROLLBACK, SAVEPOINT); constraints (PK, FK, NOT NULL, UNIQUE, CHECK); data integrity. | 08 | 3 |
| 4 | **Advanced SQL Concepts and Data Analysis** | Window functions (ROW_NUMBER, RANK, LAG, etc.); Common Table Expressions (CTEs), recursive queries; pivot/unpivot operations; temporary tables; indexing basics; data cleaning, handling outliers/missing values, feature engineering, data sampling; integration with Python (pandas.read_sql); use case – customer segmentation. | 08 | 4 |
| 5 | **Capstone Project and Industry Applications** | Capstone project using multi-table datasets; schema design for real-world problems; querying open data (Kaggle, BigQuery); connecting SQL with BI tools (Tableau, Power BI); SQL in interviews and job scenarios; project presentations and peer reviews. | 08 | 5 |

| **Reference Books:** |
|---|
| 1. **SQL for Data Scientists** by Renee M. P. Teate – Beginner-friendly, focused on data science use cases. |
| 2. **Learning SQL (3rd Edition)** by Alan Beaulieu – Comprehensive guide for mastering SQL from scratch. |
| 3. **SQL Cookbook** by Anthony Molinaro – Practical solutions for real-world SQL challenges. |
| 4. **SQL in 10 Minutes, Sams Teach Yourself** by Ben Forta – Quick, accessible SQL learning for beginners. |
| **e-Learning Source:** |
| https://onlinecourses.nptel.ac.in/noc22_cs91/preview |

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

# *Justification for CO-PO-PSO Mapping*

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT560 | **Title of the Course** | Statistical Machine Learning | **L** | **T** | **P** | **C** |
| **Year** | I | **Semester** | II | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objective is to learn the basic concept Statistical Learning | | | | | | |

**CO1: Understand relational database concepts and apply foundational SQL commands for data creation and retrieval.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO2: Write queries to filter, sort, aggregate, and group data for analysis using SQL.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO3: Perform complex data operations involving multiple tables, joins, subqueries, and set operations.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO4: Utilize advanced SQL features such as window functions, CTEs, and transactions for data manipulation and performance optimization.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped- 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3-High)

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**CO5 Apply SQL in real-world data science scenarios including data cleaning, analysis, and reporting using BI tools and capstone projects.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

| Effective from Session: 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT559 | **Title of the Course** | Time Series Analysis | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | Basic knowledge of Probability and Statistics | **Co-requisite** | None | | | | |
| **Course Objectives** | To introduce the fundamentals of statistical signal processing and time series analysis, focusing on model development, spectral analysis, and estimation techniques. The course aims to equip students with analytical tools for modeling, interpreting, and forecasting real-world signals and time-dependent data. | | | | | | |

| Course Outcomes | |
|---|---|
| **CO1** | Understand the basic concepts and components of time series data |
| **CO2** | Analyze trend and seasonal components using statistical methods |
| **CO3** | Apply autocorrelation techniques and estimation theories in time series analysis |
| **CO4** | Develop and evaluate stochastic models for time series data |
| **CO5** | Apply forecasting techniques to real-world time series data using case studies |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | Introduction and Fundamentals | **Introduction & Overview:** Purpose and scope of the subject, Applications and importance, Key terminology and foundational concepts, Basic probability concepts, Random variables and distributions, Statistical measures: mean, variance, standard deviation, Central limit theorem (brief overview) | 8 | 1 |
| 2 | Correlation Analysis | **Auto and Cross-correlation Functions:** Definition and interpretation, Mathematical formulation, Applications in time series and signal processing, Examples and visual illustrations | 8 | 2 |
| 3 | Advanced Analysis | **Partial Correlation Functions:** Concept and need for partial correlation, Difference from simple correlation, Calculation methods, Real-world applications | 8 | 3 |
| 4 | Time Series Modeling | **Auto-regressive, Moving Average, and ARMA Models:** Introduction to Time Series Models, Auto-Regressive (AR) Models, Moving Average (MA) Models, ARMA (Auto-Regressive Moving Average) Models | 8 | 4 |
| 5 | Models for non-stationary | **Models for Non-stationary Processes:** Non-stationarity in time series, Modeling trends and seasonality, Introduction to heteroskedasticity, ARIMA (Auto-Regressive Integrated Moving Average) Models | 8 | 5 |

| **Reference Books:** |
|---|
| Hamilton, J. D. (2020). Time series analysis. Princeton university press. |
| Cryer, J. D. (1986). Time series analysis (Vol. 286). Boston: Duxbury Press. |
| Kirchgässner, G., Wolters, J., & Hassler, U. (2012). *Introduction to modern time series analysis*. Springer Science & Business Media. |
| **e-Learning Source:** |
| https://onlinecourses.nptel.ac.in/noc25_cs71/preview |
| https://onlinecourses.nptel.ac.in/noc25_mg77/preview |

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 3 | - | - | - | - | - | 1 | 2 | 3 | 2 | 1 | 1 |
| **CO2** | 3 | - | - | - | - | - | 1 | 2 | 3 | 2 | 2 | 2 |
| **CO3** | 2 | - | - | - | - | - | 1 | 2 | 3 | 3 | 2 | 2 |
| **CO4** | 3 | - | - | - | - | - | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 2 | 3 | 3 | 3 | 3 | 3 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

# *Justification for CO-PO-PSO Mapping*

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT559 | **Title of the Course** | Time Series Analysis | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | Basic knowledge of Probability and Statistics | **Co-requisite** | None | | | | |

**CO1: Fundamental concepts of time series data and analysis.**

- **PO1 -Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3- High)
- **PO7 -Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 1-Low)
- **PO8 -Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 2-Moderate)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 2-Moderate)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently (Mapped as 1-Low)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 1-Low)

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**CO2: Analyze trend and seasonal components using statistical methods**

- **PO1 -Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3- High)
- **PO7 -Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 1-Low)
- **PO8 -Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 2-Moderate)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 2-Moderate)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently (Mapped as 2-Moderate)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO3: Apply autocorrelation techniques and estimation theories in time series analysis**

- **PO1 -Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 -Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 1-Low)
- **PO8 -Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 2-Moderate)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently (Mapped as 2-Moderate)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO4: Develop and evaluate stochastic models for time series data**

- **PO1 -Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 -Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 -Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 3- High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3-High)

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**CO5: Apply forecasting techniques to real-world time series data using case studies**

- **PO1 -Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 -Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 -Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped as 3- High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3-High)

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT560 | **Title of the Course** | Structured Query Language | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objective is to learn the basic concept SQL | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Understand relational database concepts and apply foundational SQL commands for data creation and retrieval. |
| **CO2** | Write queries to filter, sort, aggregate, and group data for analysis using SQL. |
| **CO3** | Perform complex data operations involving multiple tables, joins, subqueries, and set operations. |
| **CO4** | Utilize advanced SQL features such as window functions, CTEs, and transactions for data manipulation and performance optimization. |
| **CO5** | Apply SQL in real-world data science scenarios including data cleaning, analysis, and reporting using BI tools and capstone projects. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Introduction to Databases and SQL Basics** | Overview of databases and their types (Relational vs Non-relational); Introduction to RDBMS (MySQL, PostgreSQL); SQL vs NoSQL (focus on relational); SQL syntax, data types; database objects – tables, views, indexes; creating/modifying tables; data insertion; basic SELECT queries. | 08 | 1 |
| 2 | **Data Retrieval, Filtering, and Aggregation** | Retrieving data with SELECT, WHERE, ORDER BY, DISTINCT; logical and comparison operators (AND, OR, NOT, =, <>, IN, BETWEEN, LIKE); handling NULLs, using LIMIT, OFFSET, aliases; aggregate functions (COUNT, SUM, AVG, etc.); GROUP BY, HAVING, nested aggregations; case study on sales data. | 08 | 2 |
| 3 | **Working with Multiple Tables and Data Manipulation** | JOINs (INNER, LEFT, RIGHT, FULL); self-joins, aliasing, UNION, INTERSECT, EXCEPT; subqueries – scalar, correlated, derived; real-world joins (e.g., customer-orders); INSERT, UPDATE, DELETE; transaction control (COMMIT, ROLLBACK, SAVEPOINT); constraints (PK, FK, NOT NULL, UNIQUE, CHECK); data integrity. | 08 | 3 |
| 4 | **Advanced SQL Concepts and Data Analysis** | Window functions (ROW_NUMBER, RANK, LAG, etc.); Common Table Expressions (CTEs), recursive queries; pivot/unpivot operations; temporary tables; indexing basics; data cleaning, handling outliers/missing values, feature engineering, data sampling; integration with Python (pandas.read_sql); use case – customer segmentation. | 08 | 4 |
| 5 | **Capstone Project and Industry Applications** | Capstone project using multi-table datasets; schema design for real-world problems; querying open data (Kaggle, BigQuery); connecting SQL with BI tools (Tableau, Power BI); SQL in interviews and job scenarios; project presentations and peer reviews. | 08 | 5 |

| **Reference Books:** |
|---|
| 1. **SQL for Data Scientists** by Renee M. P. Teate – Beginner-friendly, focused on data science use cases. |
| 2. **Learning SQL (3rd Edition)** by Alan Beaulieu – Comprehensive guide for mastering SQL from scratch. |
| 3. **SQL Cookbook** by Anthony Molinaro – Practical solutions for real-world SQL challenges. |
| 4. **SQL in 10 Minutes, Sams Teach Yourself** by Ben Forta – Quick, accessible SQL learning for beginners. |
| **e-Learning Source:** |
| https://onlinecourses.nptel.ac.in/noc22_cs91/preview |

| | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 2 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO3** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | - | - | - | - | - | 3 | 3 | 3 | 3 | 3 | 2 |

**1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

# *Justification for CO-PO-PSO Mapping*

| **Effective from Session:** 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | MT560 | **Title of the Course** | Statistical Machine Learning | **L** | **T** | **P** | **C** |
| **Year** | I | **Semester** | II | **3** | **1** | **0** | **4** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objective is to learn the basic concept Statistical Learning | | | | | | |

**CO1: Understand relational database concepts and apply foundational SQL commands for data creation and retrieval.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO2: Write queries to filter, sort, aggregate, and group data for analysis using SQL.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO3: Perform complex data operations involving multiple tables, joins, subqueries, and set operations.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

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**CO4: Utilize advanced SQL features such as window functions, CTEs, and transactions for data manipulation and performance optimization.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 2-Moderate)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped- 3-High)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 3-High)

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**CO5 Apply SQL in real-world data science scenarios including data cleaning, analysis, and reporting using BI tools and capstone projects.**

- **PO1 Critical Thinking:** Apply advanced knowledge of data science to solve real-world data science problems (Mapped as 3-High)
- **PO7 Self-directed and lifelong learning:** Function effectively as an individual and as a member or leader in diverse teams and in multidisciplinary settings (Mapped as 2-Moderate)
- **PO8 Research related skills:** Recognize the need for and have the preparation and ability to engage in independent, life-long learning in the context of technological change (Mapped- 3-High)
- **PSO1:** Apply statistical, computational, and machine learning techniques to analyze and derive meaningful patterns from large and complex datasets. (Mapped as 3-High)
- **PSO2:** Develop domain-specific solutions by integrating data science tools with knowledge from healthcare, finance, marketing, or other relevant fields. (Mapped as 3-High)
- **PSO3:** Employ big data technologies and cloud platforms to manage and process large-scale data efficiently. (Mapped as 3-High)
- **PSO4:** Undertake research projects and contribute to innovation in data science by applying critical thinking and research methodology (Mapped as 2-Moderate)

# Integral University, Lucknow

| **Effective from Session:**2025-26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | CS566 | **Title of the Course** | Internship /Project/Minor Project in Kaggle Competition | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | **0** | **0** | **8** | **8** |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | The course objectives are to develop practical skills and professional competencies by providing hands-on training and exposure to real-world tasks and challenges, enhancing communication, teamwork, problem-solving, and adaptability within an industrial setting. Additionally, the course aims to bridge academic learning and real-world applications by applying theoretical concepts learned in academic studies to solve practical problems and contribute effectively to industry projects. Lastly, students will demonstrate proficient communication and documentation skills in reports and presentations throughout and following the industrial project/internship | | | | | | |
| *Note:- As part of the M.Sc. Data Science Internship/Project, students will explore, experiment with, or analyze technical problems across various domains of Computer Science and Engineering. This includes tasks such as software development, algorithm design, system design, software testing, data analysis, artificial intelligence, and its applications. The assessment for the Internship/Project/Minor Project in Kaggle Competition will be conducted both internally within the department and externally, following established procedures. Additionally, students are required to submit a detailed project report by the end of the fourth semester.* | | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Develop practical skills relevant to the industry through hands-on training and exposure to real-world tasks and challenges. Enhance professional competencies such as communication, teamwork, problem-solving, and adaptability within an industrial setting. |
| **CO2** | Apply theoretical concepts learned in academic studies to solve practical problems and contribute effectively to projects within the industry, bridging the gap between academic learning and real-world applications. |
| **CO3** | Work on Real World experience with Kaggle Datasets and demonstrate Proficient Communication and documentation Skills in Reports and Presentations Throughout Industrial Training / Internship |

| **Unit No.** | **Skill Set** | **Content** | **Mapped CO** |
|---|---|---|---|
| **1** | **Practical Skill Development Professional Growth** | Develop practical skills relevant to the industry through hands-on training and exposure to real-world tasks and challenges. Enhance professional competencies such as communication, teamwork, problem-solving, and adaptability within an industrial setting. | **1** |
| **2** | **Application of Theoretical Knowledge** | Apply theoretical concepts learned in academic studies to solve practical problems and contribute effectively to projects within the industry, bridging the gap between academic learning and real-world applications.**:** Defining and calling functions, Function arguments and return values, Importing and using modules, Creating and using custom modules. | **2** |
| **3** | **Real World Experience** | Demonstrate Proficient Communication/Practice ML Algorithms and work on real datasets and business problems and present documentation Skills in Reports and Presentations Throughout and Following Industrial Training / Internship. | **3** |

**Reference Books:**


**Python for Data Analysis" by Wes McKinney:** McKinney, W. (2017). *Python for Data Analysis*. O'Reilly Media.

**Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking" by Foster Provost and Tom Fawcett:** Provost, F., & Fawcett, T. (2013). *Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking*. O'Reilly Media.

**Bayesian Data Analysis" by Andrew Gelman, John B. Carlin, Hal S. Stern, David B. Dunson, Aki Vehtari, and Donald B. Rubin:** Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Vehtari, A., & Rubin, D. B. (2013). *Bayesian Data Analysis*. CRC Press.


| | **Course Articulation Matrix: (Mapping of COs with POs and PSOs)** | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | 3 | 1 | 3 | 1 | 0 | 1 | 2 | 3 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 0 | 2 | 3 | 2 | 2 | 2 | 1 | 2 |

**1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| | |
|---|---|
| **Name & Sign of Program Coordinator** | **Sign & Seal of HoD** |

| Effective from Session: 2025- 26 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Course Code** | CS568 | **Title of the Course** | Cloud Computing Basics | **L** | **T** | **P** | **C** |
| **Year** | II | **Semester** | IV | 3 | 1 | 0 | 4 |
| **Pre-Requisite** | None | **Co-requisite** | None | | | | |
| **Course Objectives** | ● To learn how to use Cloud Services. ● To implement Virtualization ● To implement Task Scheduling algorithms. ● Apply Map-Reduce concept to applications. ● To build Private Cloud. ● Broadly educate to know the impact of engineering on legal and societal issues involved | | | | | | |

| **Course Outcomes** | |
|---|---|
| **CO1** | Analyze the Cloud computing setup with it's vulnerabilities and applications using different architectures. |
| **CO2** | Design different workflows according to requirements and apply map reduce programming model. |
| **CO3** | Create combinatorial auctions for cloud resources and design scheduling algorithms for computing clouds |
| **CO4** | Assess cloud Storage systems and Cloud security, the risks involved, its impact and develop cloud application |
| **CO5** | Broadly educate to know the impact of engineering on legal and societal issues involved in addressing the security issues of cloud computing. |

| Unit No. | Title of the Unit | Content of Unit | Contact Hrs. | Mapped CO |
|---|---|---|---|---|
| 1 | **Introduction; Principles of Parallel and Distributed Computing** | Cloud computing at a glance; Historical Developments; building Cloud computing environment; computing platforms and Technologies Principles of Parallel and Distributed Computing: Eras of Computing; parallel Vs. distributed computing; elements of distributed computing; technologies of Distributed computing | 8 | 1 |
| 2 | **Virtualization and Cloud Computing Architecture** | Characteristics of virtualized environments; virtualization techniques; virtualization and cloud computing; pros and cons of virtualization; examples. Cloud Reference model; Types of clouds; cloud economics; open challenges | 8 | 2 |
| 3 | **Concurrent Computing and High-Throughput Computing and Map Reduce Programming** | Introducing parallelism; programming with threads; multithreading with Aneka; applications; Task Computing; task based Application Model; Task based Programming; Data Intensive Computing; Technologies; Aneka Map Reduce Programming | 8 | 3 |
| 4 | **Cloud Platforms in Industry and Cloud Applications** | Amazon Web services; Google App Engine; Microsoft Azure; Cloud scientific Applications; Business and Consumer Applications | 8 | 4 |
| 5 | **Advanced Topics in Cloud Computing and Cloud Security** | Energy Efficiency Clouds; Market based management clouds; Federated Clouds; Third Party Cloud Services; Infrastructure Security: Network level security, Host level security, and Application-level security; Data security and Storage | 8 | 5 |

**Reference Books:**


1. Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Cloud Computing: Principles and Paradigms, Wile, 2011
2. Barrie Sosinsky, Cloud Computing Bible, Wiley-India, 2010
3. Editors: Nikos Antonopoulos, Lee Gillam, Cloud Computing: Principles, Systems and Applications, Springer, 2012
4. Ronald L. Krutz, Russell Dean Vines, Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Wiley-India, 2010


**e-Learning Source:**

| | | Course Articulation Matrix: (Mapping of COs with POs and PSOs) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PO-PSO CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PSO1 | PSO2 | PSO3 | PSO4 |
| **CO1** | 2 | 3 | | | 1 | | | 3 | 3 | 2 | 3 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | | | | |
| **CO3** | 2 | | 2 | | | | | 2 | 3 | | 3 | 3 |
| **CO4** | 2 | 2 | | | | 2 | | | | 3 | 2 | |
| **CO5** | 3 | 2 | 3 | 2 | 3 | | | 3 | 2 | 3 | 2 | 3 |

**1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

| Name & Sign of Program Coordinator | Sign & Seal of HoD |
|---|---|