Effective from Session: 2025- 26							
Course Code	MT555	**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**

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**

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 Learn to implement and optimize deep neural network architectures Analyze and apply convolutional neural networks for image-related tasks Model sequential and time-series data using recurrent neural networks and variants Explore advanced neural models like autoencoders, GANs, and transformers 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: 2024-25							
Course Code	CS560	**Title of the Course**	Programming for Data Science with Python	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**3**	**1**	**0**	**4**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	• To comprehend basics of Data Science and equip students with the essential skills and knowledge of Python programming. • To learn and understand the core concepts of Python programming including basic syntax, data types, data structures, functions, and modules. • To be able to handle and analyze data effectively to develop efficient solutions and gain the ability to perform comprehensive statistical data analyses. • To study and implement various comprehensive Python libraries to create compelling visualizations and to perform statistical analysis. To understand the concept of Machine Learning and how to apply machine learning techniques to solve real-world problems.						

Course Outcomes	
CO1	Basic concepts and importance of Data Science and will effectively use Jupyter Notebooks, along with gaining proficiency in Python programming fundamentals, basic syntax, data types, and control structures.
CO2	Essential data structures such as lists, tuples, sets, and dictionaries for efficient data manipulation, and will also learn to define, call, and manage functions and modules.
CO3	Utilize the Pandas library for data manipulation and analysis, including reading and writing various data formats, cleaning and preparing data, performing descriptive statistics, and conducting Exploratory Data Analysis (EDA).
CO4	Create both basic and advanced plots using Matplotlib and Seaborn, customize visual elements, and learn to generate various statistical plots and interactive visualizations to interpret and present data effectively.
CO5	Understand the principles of Machine Learning, differentiate between supervised and unsupervised learning, and employ model evaluation and validation techniques. They will explore real-world applications of Machine Learning using Flask and address ethical considerations in Data Science.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to Data Science & Python**	**Understanding Data Science:** Overview of data science and its importance, Steps in a data science project, Introduction to Jupyter Notebooks. **Fundamentals of Python:** Overview of Python programming language, Python IDEs and setting up the environment, Basic syntax, variables, data types, and handling input/output **f**unctions, Control Structures: if statements, loops.	**7**	**1**
2	**Elementary Data Structures & Functions**	**Data Structures:** Lists, tuples, sets, and dictionaries, list comprehensions and dictionary comprehensions, basic operations on data structures **Functions & Modules:** Defining and calling function, function arguments and return values, importing and using modules, creating and using custom modules.	**8**	**2**
3	**Data Manipulation and Analysis with Pandas**	**Pandas Basics:** Introduction to Pandas library, Series and Data Frame objects, Reading and writing data (CSV, Excel, JSON). **Data Cleaning and Preparation:** Handling missing data, Data transformation and normalization, Merging, joining, and concatenating Data Frames. **Exploratory Data Analysis (EDA):** Descriptive statistics, Data visualization with Pandas, Grouping and aggregation.	**9**	**3**
4	**Data Visualization Database Concepts**	**Introduction to Matplotlib:** Basic plotting with Matplotlib, customizing plots (titles, labels, legends), subplots and grid plots. **Seaborn for Statistical Plots:** Introduction to Seaborn, creating various plots (histograms, box plots, violin plots), interactive plots with Plotly.	**8**	**4**
5	**Machine Learning with Scikit-Learn**	**Introduction to Machine Learning:** Overview of machine learning, supervised vs. unsupervised learning, model evaluation and validation techniques. **Model Deployment and Applications:** Model serialization and deployment with Flask, real-world applications of machine learning, ethical considerations in data science.	**7**	**5**

ReferenceBooks:

1. McKinney, W. (2017). Python for Data Analysis: Data wrangling with Pandas, NumPy, and IPython (2nd ed.). O'Reilly Media.
2. VanderPlas, J. (2016). Python Data Science Handbook: Essential Tools for Working with Data. O'Reilly Media.
3. AurélienGéron, A. (2019). Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, tools, and techniques to build intelligent systems (2nd ed.). O'Reilly Media.
4. Grus, J. (2019). Data Science from Scratch: First principles with Python (2nd ed.). O'Reilly Media.

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	1	-	-	-	-	1	1	1	1	1	1
CO2	2	1	-	-	-	-	2	1	2	1	1	1
CO3	3	2	-	-	-	-	2	1	2	2	2	1
CO4	3	2	-	-	-	-	2	2	2	3	2	1
CO5	3	2	-	-	-	-	3	2	1	2	2	1

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	CS565	**Title of the Course**	Python Programming Lab	**L**	**T**	**P**	**C**
Year	II	**Semester**	III	**0**	**0**	**2**	**2**
Pre-Requisite	None	**Co-requisite**	None				
Course Objectives	The objective of this course is to provide students with a comprehensive understanding of Python programming, including basics, data manipulation using Pandas, statistical analysis, advanced data science techniques, and data visualization with Matplotlib, equipping them with essential skills for data analysis and statistical computing in the field of Data Science.						

Course Outcomes	
CO1	Able to demonstrate proficiency in Python basics, including data structures like lists, tuples, sets, dictionaries, and arrays, through practical programming exercises
CO2	Able to utilize the Pandas library to manipulate and analyze data efficiently, including creating Series and Data Frames, and reading data from CSV files.
CO3	Able to apply statistical methods using Python to calculate key measures such as count, sum, mean, median, mode, range, variance, standard deviation, percentiles, and averages.
CO4	Able to implement advanced data science techniques, particularly linear regression, to analyze data, and interpret regression coefficients, p-values, and R-squared values using appropriate libraries.
CO5	Able to create effective data visualizations using the Matplotlib library, including line graphs, bar charts, histograms, and pie charts, and customize plots with labels, titles, and subplots

Practical

S. No.	List of Experiments	Contact Hrs.	Mapped CO
1.	***Basics of Python*** 1. **Lists:** Write a Python program to create a list of your favorite items, add & remove new items to the list and print & access the individual element of the list. 2. **Tuples:** Write a Python program to create a tuple of your favorite movies, access and print the first movie in the tuple, find & print the length of the tuple. 3. **Sets:** Write a Python program to create a set of unique numbers, add & remove a new number to the set and print the set to verify changes. 4. **Dictionary:** Write a Python program to create a dictionary to store the names and ages of your friends, adds a new friend to the dictionary, update the age of an existing friend and finally print the dictionary and access a value by its key. 5. **Arrays:** Write a Python program to create & display an array of integers using the Numpy library, calculate and print the mean of the array.	**3**	**1**
2.	***Pandas Library*** 6 **Pandas Series**: Write a Python program to create a Pandas Series from a list of numbers, print the Series, and access & print the first element of the Series. 7 **Data Frame:** Write a Python program to create a Data Frame from a dictionary of lists, print the Data Frame, access and print a specific column in the Data Frame. 8 **Reading File (CSV):** Write a Python program to read data from a CSV file into a Data Frame, print the first 5 rows of the Data Frame, and then print the column names of the Data Frame.	**4**	**2**
3.	***Statistics with Python*** 9. **Standard Operations**: Write a Python program to create a list of numbers and then calculate and print the count, sum, mean, median, and mode of the list. 10. **Statistical Operations**: Write a Python program to calculate and print the range, variance, and standard deviation of a list of numbers. 11. **Percentile, Average**: Write a Python program to calculate and print the 50th percentile (median) and average (mean) of a list of numbers	**4**	**3**
4.	***Data Science Advanced*** 12 **Linear Regression**: Write a Python program to perform linear regression on a given set of data points and print the coefficient & intercept of the regression line. 13 **Regression Table & Info**: Write a Python program to perform linear regression using stats models on a given dataset and print the regression summary table. 14 **P-Value, R-Squared**: Write a Python program to perform linear regression using stats models and print the regression coefficients, p-values, and R-squared value.	**4**	**4**
5.	***Data Visualization*** 15 **Pyplot:** Write a Python program to plot a simple line graph using Matplotlib, add markers to the line, and change the style of the line. 16 **Labels:** Write a Python program to plot a line graph, add labels to the x-axis and y-axis, add a title to the graph, and enable the grid.	**5**	**5**

6.	***Matplotlib Library*** **17 Subplot**: Write a Python program to create a figure with two subplots and plot different data in each subplot. **18 Bars**: Write a Python program to create a bar chart using Matplotlib and label the bars with corresponding values. **19 Histograms**: Write a Python program to generate random data and plot a histogram using matplotlib. **20 Pie Charts**: Write a Python program to create a pie chart using Matplotlib, add labels and percentage values to the slices.	**5**	**5**

Books recommended:

1. "***An Introduction to Python***" by Guido van Rossum and Fred L. Drake Jr. (2011), Revised & updated for Python 3.2, Network Theory Ltd.
2. "***Python for Data Analysis***" by Wes McKinney, W. (2017). Python for data analysis: Data wrangling with Pandas, NumPy, and IPython (2nd ed.). O'Reilly Media.
3. "***Python Crash Course***" by Eric Matthes (2019). Python crash course: A hands-on, project-based introduction to programming. No Starch Press.
4. "***Think Stats: Exploratory Data Analysis***" by Allen B. Downey. (2014). Think stats: Exploratory data analysis in Python. O'Reilly Media.

	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	1	-	-	-	-	1	1	1	1	1	1
CO2	2	1	-	-	-	-	2	1	2	1	1	1
CO3	3	2	-	-	-	-	2	1	2	2	2	1
CO4	3	2	-	-	-	-	2	2	2	3	2	1
CO5	3	2	-	-	-	-	2	2	1	2	2	1

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

1-

2-

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

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**

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**

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

Effective from Session: 2025- 26							
Course Code	**CS567**	**Title of the Course**	**Deep Learning using Python**	**L**	**T**	**P**	**C**
Year	**II**	**Semester**	**IV**	3	1	0	4
Pre-Requisite	**None**	**Co-requisite**	**None**				
Course Objectives	Understand core concepts of deep learning and neural networks, Gain hands-on experience with Python and key libraries for deep learning, Build and train deep learning models using TensorFlow and PyTorch, Apply CNNs and RNNs to solve real-world problems, Explore advanced topics like Autoencoders, GANs, and Transformers, Learn model evaluation, tuning, and deployment techniques, Understand ethical issues and model interpretability in AI systems						

Course Outcomes	
CO1	Understand the fundamentals of deep learning and gain proficiency in Python programming and essential libraries for data manipulation and visualization.
CO2	Design and train basic neural networks, implement backpropagation, and apply optimization techniques to improve model performance.
CO3	Develop and evaluate CNN-based models for image classification tasks and apply transfer learning for improved accuracy.
CO4	Build RNN, LSTM, and GRU models to analyze sequential data and apply them to real-world applications like text and time series.
CO5	Explore advanced deep learning techniques including GANs and Transformers, and deploy models using suitable platforms with awareness of ethical considerations.

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	**Introduction to Deep Learning and Python Foundations**	Introduction to deep learning, Neural Network Models and Classical Regression Models, Forward Propagation, Activation Functions, Deeper Networks, multilayer neural network, Applications of Deep Learning in various domains, Python Essentials for Deep Learning: Numpy, Pandas, Matplotlib, Scikit-learn, Introduction to Google Colab / Jupyter Notebooks, Anaconda, pip, virtualenv, TensorFlow, PyTorch	8	1
2	**Neural Networks and Training Deep Models**	Perceptron and Multilayer Perceptrons (MLP), Activation functions: ReLU, Sigmoid, Tanh, Loss functions: MSE, Cross-Entropy, Forward and Backward Propagation, Gradient Descent and Variants: SGD, Adam, RMSProp, Overfitting and Regularization	8	2
3	**Convolutional Neural Networks (CNNs)**	Introduction to Image Processing for Deep Learning, CNN Architecture: Convolution, Pooling, Flatten, Dense, Popular CNN architectures: LeNet, AlexNet, VGG, ResNet, Transfer Learning and Fine-Tuning, Visualization of feature maps	8	3
4	**Recurrent Neural Networks (RNNs) and Sequence Models**	Sequential Data and Time Series, RNN Architecture and Challenges (Vanishing Gradient), LSTM and GRU networks, Applications: Text generation, Sentiment Analysis, Stock prediction, Embeddings and Word2Vec.	8	4
5	**Advanced Topics and Deployment**	Autoencoders and Variational Autoencoders (VAE), Generative Adversarial Networks (GANs), Basics of Attention Mechanism and Transformers, Model Evaluation and Hyperparameter Tuning, Model Saving, Loading, and Deployment (Flask, Streamlit, ONNX), Ethical considerations and Explainable AI (XAI)	8	5

Reference Books:

1. **"Deep Learning with Python" by François Chollet**, Manning Publisher
2. "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron, O'Reilly Publisher
3. "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville, MIT Press
4. "Neural Networks and Deep Learning" by Michael Nielsen

e-Learning Source:

https://www.coursera.org/learn/practical-deep-learning-with-python

		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	3		3		2		3	3	2	2	
CO2	3	2	3		3				3	3		2
CO3	3	3	2	2				2	3	2	3	
CO4	2	2	3	1	2	3	3	3	2	3	2	2
CO5	1				2				2	3	3	3

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

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

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**