Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

SEMESTER - 3

Paper Code: BDS301
Paper Name: *Statistics for Data Science - 1*
Credits: 5

Module I: Introduction to Statistics
● Definition and scope of statistics
● Role of statistics in data science
● Types of data: categorical and numerical
● Descriptive statistics vs. inferential statistics
● Appropriate laboratory practice in R

Module II: Correlation & Simple Linear Regression
● Bivariate data: Definition, scatter diagram, Correlation & Rank correlation. Simple linear regression, principle of least squares and fitting of polynomials and exponential curves.
● Theory of attributes, consistency of data, independence and association of attributes, measures of association and contingency
● Assumptions of linear regression
● Estimating regression coefficients
● Residual analysis and model diagnostics
● Appropriate laboratory practice in R

Module III: Sampling Techniques
● Population vs. sample
● Probability and Non-probability Sampling
● Bias and sampling error
● Sample size determination
● Appropriate laboratory practice in R

Module IV: Probability Theory

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly known as West Bengal University of Technology)
Syllabus of B.Sc. in Data Science
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- Basic probability concepts: events, sample space, probability axioms
- Conditional probability and independence
- Bayes' Theorem
- Joint distribution & Random variables
- Expectation & Variance
- Appropriate laboratory practice in R

Module V: Probability Distributions
- Discrete probability distributions: Binomial, Poisson, Geometric
- Continuous probability distribution: Uniform, Exponential, Normal, Normal approximation of Binomial and Poisson
- Sampling distribution and central limit theorem
- Appropriate laboratory practice in R

Module VI: Statistical Inference - Hypothesis Testing 1
- Null and alternative hypotheses
- Type I and Type II errors, power of a test
- Test statistics and p-values
- Appropriate laboratory practice in R

References:
1. *Statistical Methods* by N. G. Das, Combined edition volume 1 & 2, McGraw Hill Education.
2. *Statistical Programming in R* by K.G. Srinivasa, G.M. Siddesh, Chetan Shetty , Sowmya B.J. , Oxford University Press
3. *A First Course in Statistical Programming with R* (3rd ed.) by Braun, W., & Murdoch, D. (2021), Cambridge University Press.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Paper Code: BDS302 & BDS392
Paper Name: *Artificial Intelligence & Machine Learning - 1 & AI ML-1 Lab*
Credits: 5 (3Th+2P)

Module 1: Introduction to Artificial Intelligence
● Definition and scope of Artificial Intelligence
● Historical overview and milestones in AI
● AI applications in various fields
● Agents and environments

Module 2: Problem Solving and Searching
● Problem-solving agents
● State space representation
● Uninformed search algorithms (breadth-first search, depth-first search)
● Informed search algorithms (heuristic search, A* algorithm)
● Appropriate laboratory work in Python/R

Module 3: Knowledge Representation and Reasoning
● Propositional logic
● First-order logic and predicate calculus
● Knowledge representation using logic
● Inference rules and resolution

Module 4: Expert Systems
● Introduction to expert systems
● Knowledge engineering process
● Rule-based systems
● Forward chaining and backward chaining

Module 5: Introduction to Statistical Learning
● Overview of statistical learning and its applications
● Supervised vs. unsupervised learning
● Bias-variance tradeoff
● Performance evaluation and cross-validation

Maulana Abul Kalam Azad University of Technology, West Bengal
(Formerly known as West Bengal University of Technology)
Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

Module 6: Linear Regression
- Simple linear regression
- Multiple linear regression
- Model assessment and selection
- Polynomial regression and model flexibility
- Appropriate laboratory work in Python/R

Module 7: Classification
- Logistic regression
- Linear discriminant analysis (LDA)
- K-nearest neighbors (KNN) classification
- Model evaluation and validation techniques
- Appropriate laboratory work in Python/R

Module 8: Resampling Methods
- Cross-validation
- Bootstrap methods for estimating standard errors
- Model selection using cross-validation and bootstrapping
- Appropriate laboratory work in Python/R

Module 9: Dimensionality Reduction
- Principal Component Analysis (PCA)
- Singular Value Decomposition (SVD)
- Applications of dimensionality reduction
- Appropriate laboratory work in Python/R

Module 10: Introduction to Machine Learning
- Overview of different machine learning algorithms
- Decision Trees and Random Forests
- Support Vector Machines (SVM)
- Ensemble methods (bagging and boosting)
- Appropriate laboratory work in Python/R

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

Module 11: Unsupervised Learning
- K-means clustering
- Hierarchical clustering
- Association rules and market basket analysis
- Anomaly detection
- Appropriate laboratory work in Python/R

References:
1. Dan W. Patterson (1990). *Introduction to artificial intelligence and expert systems*. Englewood Cliffs, N.J : Prentice Hall
2. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). *An introduction to statistical learning* with applications in R *(2nd ed.)*. Springer.
3. James, G., Witten, D., Hastie, T., & Tibshirani, R. (2023). *An introduction to statistical learning* with applications in Python *(1st ed.)*. Springer.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

SEMESTER - 4

Paper Code: BDS401
Paper Name: *Statistics for Data Science - 2*
Credits: 4

Module 1: Multiple Linear Regression
- Multiple regression model and interpretation of coefficients
- Model selection techniques: forward selection, backward elimination, etc.
- Assumptions and diagnostics in multiple regression: Collinearity, Heteroscedasticity & Autocorrelation
- Appropriate laboratory practice in R

Module 2: Statistical Inference - Hypothesis Testing 2
- Tests for means
- Tests for proportions
- Tests for variances
- Testing of correlation & regression coefficients
- Appropriate laboratory practice in R

Module 3: ANOVA & DOE
- One-way classified data, two-way classified data with equal number of observations per cell
- Concepts of multiple correlation and partial correlation coefficients.
- Two-way classified data with equal number of observations per cell
- Factorial experiments and interaction effects
- Analysis of variance (ANOVA) for experimental data
- Appropriate laboratory practice in R

Module 4: Nonparametric Methods
- Chi-square test
- Wilcoxon signed-rank test and Mann-Whitney U test
- Kruskal-Wallis test and Friedman test

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

- Rank correlation: Spearman's rank correlation coefficient
- Appropriate laboratory practice in R

References:
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2. *Statistical Programming in R* by K.G. Srinivasa, G.M. Siddesh, Chetan Shetty , Sowmya B.J. , Oxford University Press
3. *A First Course in Statistical Programming with R* (3rd ed.) by Braun, W., & Murdoch, D. (2021), Cambridge University Press.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

Paper Code: BDS402 & BDS492
Paper Name: *Artificial Intelligence & Machine Learning - 2 & AI ML-2 Lab*
Credits: 4 (2Th+2P)

1. **Introduction to Artificial Neural Networks**
○ Historical overview and motivations
○ Biological inspiration and neuron model
○ Basic components of neural networks
○ Types of neural networks (e.g. feedforward, recurrent)
2. **Perceptrons and Activation Functions**
○ McCulloch - Pitt Neuron & Single-layer perceptron model
○ Activation functions and their properties
○ Multilayer perceptron architecture
○ Training and learning algorithms for perceptrons
○ Appropriate laboratory work in Python/R
3. **Feedforward Neural Networks**
○ Feedforward network structure and architecture
○ Forward propagation and activation functions
○ Backpropagation algorithm for training
○ Overfitting, underfitting, and regularization techniques
○ Appropriate laboratory work in Python/R
4. **Radial Basis Function Networks**
○ Introduction to radial basis functions
○ RBF network architecture and training
○ Applications of RBF networks in pattern recognition
○ Appropriate laboratory work in Python/R
5. **Self-Organizing Maps**
○ Introduction to Kohonen Self-Organizing Maps (SOMs)
○ SOM architecture and learning algorithm
○ Clustering and visualization using SOMs

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

- Applications of SOMs in data analysis
- Appropriate laboratory work in Python/R

6. Hopfield Networks
- Introduction to associative memory
- Hopfield network architecture and energy function
- Pattern storage and retrieval in Hopfield networks
- Applications of Hopfield networks in optimization problems
- Appropriate laboratory work in Python/R

7. Neural Networks in Pattern Recognition
- Feature extraction and selection techniques
- Handwritten digit recognition using neural networks
- Face recognition using neural networks
- Applications of neural networks in image classification
- Appropriate laboratory work in Python/R

References:

1. "Neural Networks and Learning Machines" by Simon Haykin. Publisher: Pearson Date of Publication: 2021
2. "Pattern Recognition and Machine Learning" by Christopher Bishop Publisher: Springer, 2006
3. "Neural Networks and Deep Learning" by Charu C. Aggarwal, Springer
4. "Principles of Soft Computing. 2nd Edition" by Sivanandam, S.N. and Deepa, S.N. (2009), John Wiley & Sons, Inc.

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

Paper Code: BDS403 & BDS493
Paper Name: *Python for Data Science & Python for Data Science Lab*
Credits: 5 (3Th+2P)

Module 1: Emerging Trends in Computing and Role of Python
- Artificial Intelligence (AI)
- Big Data
- Internet of Things (IoT)
- Cloud Computing
- Grid Computing
- Blockchains

Module 2: Overview of Python
- Introduction to Python
- Python Keywords and Identifiers
- Variables and Data Types
- Operators and Expressions
- Input and Output
- Debugging
- Functions
- `if..else` Statements
- `for` Loops, `while` Loops and Nested Loops

Module 3: Working with Lists and Dictionaries
- Introduction to List
- List Operations
- Traversing a List
- List Methods and Built-in Functions
- List Manipulation
- Introduction to Dictionaries
- Traversing a Dictionary
- Dictionary Methods and Built-in Functions

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
Effective from academic session 2023-2024

- Manipulating Dictionaries

Module 4: Understanding Data under Python
- Introduction to Data
- Data Collection
- Data Storage
- Data Processing
- Statistical Techniques for Data Processing

Module 5: Introduction to NumPy
- Introduction
- Array and NumPy Array
- Indexing and Slicing
- Operations on Arrays
- Concatenating Arrays
- Reshaping Arrays
- Splitting Arrays
- Statistical Operations on Arrays
- Loading Arrays from Files
- Saving NumPy Arrays in Files on Disk

Module 6: Data Handling Using Pandas - I
- Introduction to Python Libraries
- Series
- DataFrame
- Importing and Exporting Data between CSV
- Files and DataFrames
- Pandas Series Vs NumPy *ndarray*

Module 7: Data Handling Using Pandas - II
- Introduction to Descriptive Statistics
- Data Aggregations

Maulana Abul Kalam Azad University of Technology, West Bengal
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Syllabus of B.Sc. in Data Science
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- Sorting a DataFrame
- GROUP BY Functions
- Altering the Index
- Other DataFrame Operations
- Handling Missing Values
- Import and Export of Data between Pandas and MySQL

Module 8: Plotting Data Using Matplotlib

- Introduction
- Plotting using Matplotlib
- Customisation of Plots
- The Pandas Plot Function (Pandas Visualisation)

Module 9: Minor Project using Python

- Introduction to Project Based Learning
- Approaches for Solving Projects
- Importance of Teamwork
- Project Planning, Execution and Reporting

References:

1. *Python Training Guide* - Mercury Learning & Information, BPB Publications.
2. *Python Data Science Handbook: Essential Tools for Working with Data* - Jake VanderPlas, O'Reilly Inc.
3. *Mastering Python for Data Science* (1st ed.) - Samir Madhavan (2015), Packt Publishing.
4. *Python Official Documentation* - The Python Software Foundation, http://www.python.org