Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce, Baramati

(Autonomous)

M.Sc. Degree Program in Data Science

(Faculty of Science & Technology)

CBCS Syllabus

M.Sc.(Data Science) Part – I Semester – I

For Department of Statistics

Tuljaram Chaturchand Collegeof Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2023-2024

Title of the Programme: M.Sc. (Data Science)Part – I

Preamble

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moralcapacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students.By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Statistics and related subjects, the Board of Studies in Statistics at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the first semester of M.Sc. Data Science, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrF, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

The preamble of an MSc Data Science course typically provides an overview and introduction to the program, outlining its objectives, structure, and key features. It sets the context and expectations for students pursuing a Master's degree in Data Science.

The Master of Science (MSc) in Data Science program is designed to equip students with the knowledge, skills, and expertise necessary to excel in the rapidly evolving field of

data science. This interdisciplinary program combines principles and techniques from statistics, computer science, and domain-specific areas to enable students to extract actionable insights and make data-driven decisions.

The MSc Data Science program is structured to provide a balance between theoretical foundations, practical skills, and hands-on experience. The curriculum consists of a combination of core courses, elective courses, and a capstone project. The program also offers opportunities for specialization in areas such as machine learning, big data analytics, natural language processing, or business analytics.

Upon successful completion of the MSc Data Science program, graduates will be equipped with the knowledge and skills to take on roles such as data scientists, data analysts, machine learning engineers, or data consultants in diverse industries, including finance, healthcare, e-commerce, and technology.

Overall, revising the M.Sc. Data Science syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

Programme Specific Outcomes (PSOs)

PSO1. Advanced Data Analysis: Apply advanced statistical and machine learning techniques to analyze complex datasets, identify patterns, and derive actionable insights.

PSO2. Data Visualization and Communication: Effectively visualize and communicate data insights through compelling visualizations, reports, and presentations.

PSO3. Statistical Computing and Programming: Utilize statistical software packages, such as R, Python, Pawer BI, SQL etc. to implement statistical analyses and simulations.

PSO4. Research and Problem-Solving: Identify research problems, formulate appropriate hypotheses, and design research studies.

PSO5. Statistical Consulting and Collaboration: Collaborate with researchers, scientists, and professionals from various domains to provide statistical support and consultancy.

PSO6. Ethical and Legal Considerations: Understand and navigate ethical and legal challenges related to data privacy, security, and governance in the field of data science.

PSO7. Deep Learning: Apply deep learning algorithms and neural networks to solve complex data analysis problems, such as image recognition and natural language processing.

PSO8. Predictive Modeling: Build predictive models using machine learning algorithms to make accurate predictions and forecasts.

PSO8.Data Mining and Knowledge Discovery: Utilize data mining techniques to extract valuable knowledge and patterns from large and complex datasets.

Anekant Education Society's

Tuljaram Chaturchand College,Baramati

(Autonomous)

Board of Studies (BOS) in Statistics

From 2022-23 to 2024-25

Sr.No.	Name	Designation
1.	Prof. Dr. Vikas C. Kakade	Chairman
2.	Prin. Dr. Avinash S. Jagtap	Member
3.	Dr. Neeta K. Dhane	Member
4.	Dr.Vaishali V. Patil	Member
5.	Mrs.Sarita D. Wadkar	Member(Ad hoc)
6.	Mr.Chandrashekhar P. Swami	Member
7.	Ms.Priti M. Mohite	Member(Ad hoc)
8.	Ms.Nilambari A. Jagtap	Member (Ad hoc)
9.	Miss.Kalyani C. Kale	Member (Ad hoc)
10.	Ms.Pooja S. Zanjurne	Member (Ad hoc)
11.	Dr.Akanksha S. Kashikar	Vice-Chancellor Nominee
12.	Prin. Dr.Rajendra G. Gurao	Expert from other University
13.	Mr.RohanKoshti	Expert from other University
14.	Mr.SaurabhKadam	Industry Expert
15.	Dr. Jaya L. Limbore	Meritorious Alumni
16.	Miss. Priya N. Rakate	Invitee Member
17.	Ms.Ankita G. Deshmukh	Invitee Member
18.	Ms.Shital B. Choudhar	Invitee Member

19.	Miss. Kiran Banda (M.Sc. II)	Student Representative
20.	Mr.RushikeshPandhare (M.Sc. II)	Student Representative
21.	Mr. Bharat Jambhulkar (TYBSc)	Student Representative
22.	Miss. Prapti Mane (TYBSc)	Student Representative

Credit Distribution Structure for M.Sc.(Data Science)Part-I

Level	Semester	Major		Research Methodology (RM)	OJT/FP	RP	Cum. Cr.	Degree
		Mandatory	Electives					
6.0	Sem-I	DSC-501-MJM: Probability and Statistics for Data Science(Credit 04) DSC-502-MJM: Data Analytics Using R(Credit 04) DSC -503-MJM: Data Science Practical – I (Credit 02) DSC-504-MJM: Data Science Practical – II (Credit 02)	DSC-511-MJE (A): Data Base Management System DSC -511-MJE (B): Stochastic Models and Applications (Credit 04)	DSC -521-RM: Research Methodology (Credit 04)	--	--	20	PG Diploma (after 3 Year Degree)
	Sem-II	DSC -551-MJM: Machine Learning and Artificial intelligence(Credit 04) DSC-552-MJM: Regression Analysis and Predictive Models (Credit 04) DSC-553-MJM: Data Science Practical – III (Credit 02) STA -554-MJM: Data Science Practical – IV (Credit 02)	DSC -561-MJE (A): Bayesian Inference DSC -561-MJE (B): Computational Statistics (Credit 04)	--	DSC-581-OJT/FP: On Job Training/ Field Project	--	20	

Course Structure for M.Sc. Part-I (Statistics)(2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	DSC-501-MJM	Probability and Statistics for Data Science	Theory	04
	Major (Mandatory)	DSC -502-MJM	Data Analytics Using R	Theory	04
	Major (Mandatory)	DSC -503-MJM	Data Science Practical – I	Practical	02
	Major (Mandatory)	DSC -504-MJM	Data Science Practical – II	Practical	02
	Major (Elective)	DSC-511-MJE (A)	Data Base Management System	Theory	04
		DSC -511-MJE (B)	Stochastic Models and Applications	Theory	
	Research Methodology (RM)	DSC -521-RM	Research Methodology	Theory	04
				Total Credits Semester I	**20**
II	Major (Mandatory)	DSC -551-MJM	Machine Learning and Artificial intelligence	Theory	04
	Major (Mandatory)	DSC-552-MJM	Regression Analysis and Predictive Models	Theory	04
	Major (Mandatory)	DSC-553-MJM	Data Science Practical – III	Practical	02
	Major (Mandatory)	DSC-554-MJM	Data Science Practical – IV	Practical	02
	Major (Elective)	DSC -561-MJE (A)	Bayesian Inference	Theory	04
		DSC -561-MJE (B)	Computational Statistics	Theory	
	On Job Training (OJT)/Field Project (FP)	DSC -581-OJT/FP	On Job Training Field Project	Training/Project	04
				Total Credits Semester-II	**20**
				Cumulative Credits Semester I and II	**40**

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	**:** M.Sc. Data Science
Program Code	**:** PSDSC
Class	**:** M.Sc. Part – I
Semester	**:** I
Course Type	**:** Major Mandatory Theory
Course Name	**:** Probability and Statistics for Data Science
Course Code	**:** DSC-501-MJM
No. of Credits	**:** 4
No. of Teaching Hours	**:** 60

Course Objectives:

1. To provide a thorough understanding of fundamental concepts in probability and statistics necessary for data science.
2. To develop a solid foundation in probabilistic models and statistical inference.Apply probability distributions to real-world scenarios.
3. To learn and apply essential statistical methods for data analysis, including hypothesis testing, confidence intervals, and regression analysis.
4. To develop the ability to perform and interpret various statistical tests.
5. To apply probabilistic and statistical techniques to real-world data science problems.
6. To analyze datasets from diverse domains to derive meaningful insights and make data-driven decisions.
7. To discuss the ethical considerations in data collection, analysis, and interpretation.

Course Outcomes:

By the end of the course, students will be able to:

CO1. Demonstrate a thorough understanding of the basic concepts of probability, including random experiments, algebra of events, and laws of probability.

CO2. Apply conditional probability, the concept of independence, and Bayes' law to solve problems in business and economics.

CO3. Describe and analyze one-dimensional random variables (both discrete and continuous) and their distribution functions

CO4. Define, describe properties, and apply Uniform, Normal, Exponential, Gamma, and Beta distributions, including truncated distributions.

CO5. Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing.

CO6. Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations.

CO7. Use the concept of pivotal quantities to derive confidence intervals for various statistical measures, including the median and quartiles.

Topics and Learning Points

Unit 1: **(15 L)**

Probability and Random Variables: Introduction – Random Experiments, Empirical basis of probability, Algebra of events, laws of Probability; Conditional Probability, Independence, Bayes' law; Application of probability to business and economics. One-dimensional Random variable- Discrete and Continuous; Distribution functions and its properties; Bivariate Random Variables- Joint Probability functions, marginal distributions, conditional distribution functions, Notion of Independence of Random variables.

Unit 2: **(15 L)**

Discrete Distributions: Bernoulli, Binomial, Poisson, Geometric, Hypergeometric, Negative Binomial, Multinomial, distributions and Discrete Uniform distribution - definition, properties and applications with numerical problems.

Continuous Distributions: Uniform, Normal, Exponential, Gamma, Beta distributions (First and Second kind), - definition, properties and applications; concept of truncated distributions.

Sampling Distributions: Introduction, The sampling distribution of the Mean: Finite Populations, Sampling distribution of the proportion: Finite Populations, distribution of sample variance, the chi-square distribution, the t distribution, the F distribution, order statistics: properties, and applications, procedure of hypothesis testing.

Unit3: **(18 L)**

Point Estimation: Point Estimation- Estimator, Estimate, Methods of point estimation – Maximum likelihood Method, Method of moments, method of Least squares, and applications.Population, sample, parameter and statistic; characteristics of a good estimator, Unbiasedness, Minimum Variance Unbiased Estimator, Sufficiency, Factorization Theorem,

Minimal sufficiency, Efficiency, Most Efficient estimator, likelihood equivalence, and, Consistency, invariance property of Consistent estimator.

Unit 4: (12 L)

Interval estimation confidence limits and confidence coefficient: Notion of interval estimation, definition of confidence interval (C.I), length of C.I., Confidence bounds, confidence coefficient. Definition of pivotal quantity and its use in obtaining confidence intervals.Construction of confidence intervals for population proportion and between two population proportions, Confidence intervals for mean and variance of a normal population, Difference between the Mean of two normal populations.Construction of confidence intervals for Median, quartiles using order statistics.

References:

1. ParimalMukhopadhyay; An Introduction to the Theory of Probability, World scientific, 2012.
2. Irwin Miller, Marylees Miller, John E. Freund's; Mathematical Statistics, Pearson, 2017.
3. FetsjeBijma, Marianne Jonker and AadvanderVaart; Introduction to Mathematical Statistics, Amsterdam University Press, 2018.
4. Krishnamoorthy, K., Handbook of Statistical Distributions with Applications, Chapman & Hall/CRC, 2006.
5. Shanmugam, R., Chattamvelli, R. Statistics for scientists and engineers, John Wiley, 2015.
6. Casella G. and Beregar R.L. (2002) Statistical Inference, 2nd Edition (Duxbury Advanced Series)
7. Dudewitz E.J. & Mishra S.N.(1988) Modern Mathematical Statistics (John Wiley)
8. Kale B.K. (1999) A First course on Parametric Inference (Narosa)
9. Lehman E.L (1988) Theory of point estimation (John Wiley)
10. Lehman E.L(1986) Testing of Statistical hypotheses (John Wiley)
11. Rohatagi V.K. (1976) Introduction to theory of probability & mathematical statistics (John Wiley & sons)

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	1	2	1	2	2	1
CO2	1	2	2	1	3	1	0	1	2
CO3	2	1	1	3	1	1	0	1	1
CO4	2	1	1	3	1	1	0	1	1
CO5	3	3	2	2	3	1	3	2	2
CO6	2	3	1	1	3	2	2	1	1
CO7	1	1	0	1	1	2	2	0	1

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1: Comprehensive Knowledge and Understanding

- **CO1:** Demonstrate a thorough understanding of the basic concepts of probability, including random experiments, algebra of events, and laws of probability. (Weightage: 3)
- **CO3:** Describe and analyze one-dimensional random variables (both discrete and continuous) and their distribution functions. (Weightage: 2)
- **CO4:** Define, describe properties, and apply Uniform, Normal, Exponential, Gamma, and Beta distributions, including truncated distributions. (Weightage: 2)

Justification: These COs ensure students have a strong foundation in probability and statistics, which is crucial for a comprehensive understanding of their field of study.

PO2: Practical, Professional, and Procedural Knowledge

- **CO2:** Apply conditional probability, the concept of independence, and Bayes' law to solve problems in business and economics. (Weightage: 2)
- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 3)

- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 3)

Justification: These COs are essential for applying statistical knowledge in practical, real-world scenarios and understanding industry standards and best practices.

PO3: Entrepreneurial Mindset and Knowledge

- **CO2:** Apply conditional probability, the concept of independence, and Bayes' law to solve problems in business and economics. (Weightage: 2)
- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 2)

Justification: These COs foster an entrepreneurial mindset by teaching students how to use probability and statistics to identify opportunities and manage risks.

PO4: Specialized Skills and Competencies

- **CO3:** Describe and analyze one-dimensional random variables (both discrete and continuous) and their distribution functions. (Weightage: 3)
- **CO4:** Define, describe properties, and apply Uniform, Normal, Exponential, Gamma, and Beta distributions, including truncated distributions. (Weightage: 3)

Justification: These COs develop specialized analytical skills and competencies essential for technical and problem-solving tasks in the field of data science.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning

- **CO1:** Demonstrate a thorough understanding of the basic concepts of probability, including random experiments, algebra of events, and laws of probability. (Weightage: 2)
- **CO2:** Apply conditional probability, the concept of independence, and Bayes' law to solve problems in business and economics. (Weightage: 3)
- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 3)

Justification: These COs enhance students' capacity to apply theoretical knowledge, solve complex problems, and perform analytical reasoning.

PO6: Communication Skills and Collaboration

- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 2)
- **CO7:** Use the concept of pivotal quantities to derive confidence intervals for various statistical measures, including the median and quartiles. (Weightage: 2)

Justification: These COs develop students' ability to communicate complex statistical information effectively and collaborate with others.

PO7: Research-related Skills

- **CO1:** Demonstrate a thorough understanding of the basic concepts of probability, including random experiments, algebra of events, and laws of probability. (Weightage: 2)
- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 3)
- **CO7:** Use the concept of pivotal quantities to derive confidence intervals for various statistical measures, including the median and quartiles. (Weightage: 2)

Justification: These COs equip students with the necessary skills to formulate research questions, utilize appropriate methodologies, and report findings effectively.

PO8: Learning How to Learn Skills

- **CO1:** Demonstrate a thorough understanding of the basic concepts of probability, including random experiments, algebra of events, and laws of probability. (Weightage: 2)
- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 2)

Justification: These COs foster self-directed learning and the ability to adapt to new knowledge and changing demands.

PO9: Digital and Technological Skills

- **CO2:** Apply conditional probability, the concept of independence, and Bayes' law to solve problems in business and economics. (Weightage: 2)
- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 2)

Justification: These COs ensure students are proficient in using statistical software and tools for data analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 1)
- **CO7:** Use the concept of pivotal quantities to derive confidence intervals for various statistical measures, including the median and quartiles. (Weightage: 1)

Justification: These COs, while not directly related, contribute to understanding diverse perspectives through statistical analysis.

PO11: Value Inculcation and Environmental Awareness

- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 1)

Justification: This CO ensures students understand the importance of accuracy and integrity in statistical reporting, indirectly promoting ethical values.

PO12: Autonomy, Responsibility, and Accountability

- **CO5:** Understand and apply the concepts of sampling distributions, including those of the mean, proportion, sample variance, chi-square distribution, t distribution, F distribution, and order statistics, and perform hypothesis testing. (Weightage: 2)

- **Justification:** This CO promotes independence and responsibility in conducting and reporting statistical analyses.

PO13: Community Engagement and Service

- **CO6:** Construct and interpret confidence intervals for population parameters, including population proportion, mean, variance, and differences between means of normal populations. (Weightage: 1)

Justification: This CO indirectly supports community engagement by emphasizing accurate data analysis and reporting for community-related studies.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Theory
Course Name	: Data Analytics Using R
Course Code	: DSC-502-MJM
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

Students successfully completing this course will be able to:

1. Provide an overview of R and RStudio, including installation, basic operations, and the use of R as a calculator for arithmetic and logical operations.
2. Develop a solid understanding of different data types (numeric, integer, character, logical, factor) and how to create, index, and operate on various data structures.
3. Enable students to generate random samples from different probability distributions and compute probabilities, cumulative probabilities, and quantiles.
4. Teach students to test the normality of data using the Shapiro-Wilk test and interpret the results.
5. Introduce the concepts of null and alternative hypotheses, type I and type II errors, and conduct various parametric (z test, t test, ANOVA) and non-parametric tests.
6. Provide a thorough understanding of control structures (if-else, for loops, while loops, repeat loops) and their use in R programming.
7. Develop skills in writing R programs, including debugging and error handling, to solve data analysis problems effectively.

Course Outcomes:

By the end of the course, students will be able to:

CO1. Demonstrate the ability to install, navigate, and utilize R and RStudio for data analysis tasks.

CO2. Identify and manipulate different data types (numeric, integer, character, logical, factor) and data structures (vectors, matrices, lists, data frames, factors) in R.

CO3. Read, write, and manipulate data from various sources (CSV, Excel, text files)

and create diverse types of plots (pie charts, bar charts, scatter plots, histograms, boxplots) using basic R functions and ggplot2.

CO4. Generate random samples from various probability distributions and compute probabilities, cumulative probabilities, and quantiles.

CO5. Create graphs of probability mass functions (pmf) and probability density functions (pdf) and fit probability distributions to data.

CO6. Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape (mean, mode, median, quartiles, variance, standard deviation, skewness, kurtosis).

CO7. Implement control structures (if-else, for loops, while loops, repeat loops) in R to automate and streamline data analysis tasks.

Topics and Learning Points

Unit 1: Introduction to R **(15 L)**

Overview of R and RStudio, Installing R and RStudio, R as a calculator, Arithmetic, logical, and assignment operations, Data types:Numeric, integer, character, logical, and factor. Creation, indexing, and operations on Data structures:Vectors, matrices, lists, data frames, and factors.cat and print commands. Basic functions and operations on data structures, Reading and writing data in R (CSV, Excel, text files, etc.), Creating various types of plots: Pie chart, bar chart, group bar chart, stacked bar chart, scatter plots, line plots, histograms, boxplots and ggplot

Unit2: Probability Distributions with R **(12 L)**

Generating random samples from probability distributions, computations of probabilities, cumulative probabilities, and quantiles.Graphs of pmf/pdf by varying parameters of the distributions.Fitting probability distributions to data, Testing normality of data by Shapiro Wilks test.

Unit3: Statistical Analysis with R **(18 L)**

Descriptive statistics: mean, mode, median, quartiles, minimum and maximum value, percentiles, variance, standard deviation, coefficient of variation, covariance and correlation, moments, skewness and kurtosis. Hypothesis testing: Null and alternative hypotheses, type I and type II errors, Parametric test: z test, t test, proportion test, variance test, chi-square test,

correlation test and ANOVA. Non-parametric tests: Bartlett's test for homoscedasticity, Kruscal Wallis test, Kolmogorov Smirnov test, Sign test, Sign test for paired data, Wilcoxon's signed rank test, Mann Whitney test.

Unit4: Programming in R **(12 L)**

Control structures: If-else, for loops, while loops, repeat loops. Functions in R: Defining and calling functions, scoping rules. Apply family of functions: apply, lapply, sapply, tapply, mapply. Statements: if and if…else, for loop, while loop, Writing programs in R.Debugging and error handling in R.

References:

1. Hadley Wickham & Garrett Grolemund.R for Data Science
2. Norman Matloff.The Art of R Programming
3. Hadley Wickham. Advanced R
4. George Casella and Roger L. Berger. Statistical Inference. by
5. David S. Moore, George P. McCabe, and Bruce A. Craig.Introduction to the Practice of Statistics"
6. Crawley, M. J. (2006). Statistics - An introduction using R. John Wiley, London
7. Purohit, S.G.; Gore, S.D. and Deshmukh, S.R. (2015). Statistics using R, second edition. Narosa Publishing House, New Delhi.
8. Online resources and R documentation

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	1	1	1	0	2	2
CO2	2	2	1	3	1	1	0	1	3
CO3	1	3	2	2	1	2	0	1	3
CO4	1	2	2	1	3	1	0	1	1
CO5	1	1	1	1	3	1	2	0	1
CO6	1	2	1	3	3	2	3	1	1
CO7	1	3	0	1	2	1	0	3	1

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1: Comprehensive Knowledge and Understanding

- **CO1:** Demonstrate the ability to install, navigate, and utilize R and RStudio for data analysis tasks. (Weightage: 3)
- **CO2:** Identify and manipulate different data types and data structures in R. (Weightage: 2)

Justification: These COs ensure students have a foundational understanding of R, which is crucial for comprehensive knowledge in data science.

PO2: Practical, Professional, and Procedural Knowledge

- **CO3:** Read, write,and manipulate data from various sources and create diverse types of plots using basic R functions and ggplot2. (Weightage: 3)
- **CO7:** Implement control structures in R to automate and streamline data analysis tasks. (Weightage: 3)

Justification: These COs focus on practical skills and professional knowledge essential for real-world data analysis tasks.

PO3: Entrepreneurial Mindset and Knowledge

- **CO3:** Read, write, and manipulate data from various sources and create diverse types of plots using basic R functions and ggplot2. (Weightage: 2)
- **CO4:** Generate random samples from various probability distributions and compute probabilities, cumulative probabilities, and quantiles. (Weightage: 2)

Justification: These COs help cultivate an entrepreneurial mindset by enabling students to identify opportunities through data visualization and statistical analysis.

PO4: Specialized Skills and Competencies

- **CO2:** Identify and manipulate different data types and data structures in R. (Weightage: 3)
- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 3)

Justification: These COs develop specialized analytical skills and competencies essential for technical tasks in data science.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning

- **CO4:** Generate random samples from various probability distributions and compute probabilities, cumulative probabilities, and quantiles. (Weightage: 3)
- **CO5:** Create graphs of probability mass functions (pmf) and probability density functions (pdf) and fit probability distributions to data. (Weightage: 3)

Justification: These COs enhance students' capacity to apply theoretical knowledge, solve complex problems, and perform analytical reasoning.

PO6: Communication Skills and Collaboration

- **CO3:** Read, write, and manipulate data from various sources and create diverse types of plots using basic R functions and ggplot2. (Weightage: 2)
- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 2)

Justification: These COs develop students' ability to communicate complex statistical information effectively and collaborate with others.

PO7: Research-related Skills

- **CO5:** Create graphs of probability mass functions (pmf) and probability density functions (pdf) and fit probability distributions to data. (Weightage: 2)
- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 3)

Justification: These COs equip students with the necessary skills to formulate research questions, utilize appropriate methodologies, and report findings effectively.

PO8: Learning How to Learn Skills

- **CO1:** Demonstrate the ability to install, navigate, and utilize R and RStudio for data analysis tasks. (Weightage: 2)

- **CO7:** Implement control structures in R to automate and streamline data analysis tasks. (Weightage: 3)

Justification: These COs foster self-directed learning and the ability to adapt to new knowledge and changing demands.

PO9: Digital and Technological Skills

- **CO2:** Identify and manipulate different data types and data structures in R. (Weightage: 3)
- **CO3:** Read, write, and manipulate data from various sources and create diverse types of plots using basic R functions and ggplot2. (Weightage: 3)

Justification: These COs ensure students are proficient in using statistical software and tools for data analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO3:** Read, write, and manipulate data from various sources and create diverse types of plots using basic R functions and ggplot2. (Weightage: 1)
- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 1)

Justification: These COs contribute to understanding diverse perspectives through data analysis and visualization.

PO11: Value Inculcation and Environmental Awareness

- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 1)

Justification: This CO ensures students understand the importance of accuracy and integrity in statistical reporting, indirectly promoting ethical values.

PO12: Autonomy, Responsibility, and Accountability

- **CO7:** Implement control structures in R to automate and streamline data analysis tasks. (Weightage: 2)

Justification: This CO promotes independence and responsibility in conducting and reporting statistical analyses.

PO13: Community Engagement and Service

- **CO6:** Calculate and interpret descriptive statistics, including measures of central tendency, variability, and distribution shape. (Weightage: 1)

Justification: This CO indirectly supports community engagement by emphasizing accurate data analysis and reporting for community-related studies.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Practical
Course Name	: Data Science Practical – I
Course Code	: DSC-503-MJM
No. of Credits	: 2
No. of Teaching Hours	: 60

Course Objectives:

1. Students should be able to review the core topics in probability and statistics through the study and practice of data analysis and graphical interpretation using statistical software.
2. Students will learn to use numerical computing tools and programming languages, such as MATLAB, Python, or R, to implement and solve linear algebra problems
3. Students should be able to solve systems of linear equations using various methods.
4. Students will explore applications of linear algebra in data analysis and machine learning.
5. Students should be able to plots different probability distributions and draw a model sample from it.
6. Students will develop a deep understanding of common probability distributions.
7. Students will gain experience in applying probability distributions to real-world data analysis problems.

Course Outcomes:

By the end of the course, students will be able to:

CO1. usestatistical software, packages such as R, Python, MATLAB, SPSS or Minitab to implement and analyze real life situations.

CO2. acquire skills in solving systems of linear equations using various techniques.

CO3. construct the orthogonal matrix associated with a non-singular matrix through a Gram-Schmidthorthogonalization process, diagonalization of a symmetric matrix, the role of eigenvalues, eigenvectors, Cayley Hamilton theorem in theory of

matrices etc.

CO4. develop critical thinking skills to analyze and solve problems by using linear algebra concepts.

CO5. understand various discrete and continuous probability distributions along with their real-life applications.

CO6. proficient in using simulation techniques to generate random samples from specific probability distributions.

CO7. apply appropriate probability distributions to model and analyze real-world data sets from various fields.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Matrix Operations in R
2.	Computation of generalised Inverse and MPG-Inverse
3.	Matrix Inversion Using LU Decomposition
4.	Computation of Eigen values and Eigenvectors of a Given Matrix
5.	Performing Spectral Decomposition of Symmetric Matrices
6.	Matrix Power Calculation via Eigen value and Eigenvector Methods
7.	Solution of Linear Systems Using the Gauss Elimination Method
8.	Solution of Linear Systems Using the Gauss-Jordan Method, Gauss-Seidel
9.	Verification and Application of the Cayley-Hamilton Theorem
10.	Classification and Reduction of Quadratic Forms Using eigen values and Eigenvectors
11.	Plotting of density function of univariate Probablity distribution- I
12.	Ploting of density function of univariate Probablity distribution- II
13.	Computation of probability of events related to discrete and continuous probbality distribution
14.	Point Estimation Techniques: Computing MLE, method of moments, and evaluating properties of estimators.
15.	Construction and comparison of confidence Interval.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	3	3	2	1	3
CO2	2	3	1	3	2	2	1	1	2
CO3	1	3	1	3	2	1	1	1	2
CO4	2	3	1	3	2	2	1	1	2
CO5	2	3	1	3	3	3	2	1	3
CO6	1	3	1	3	2	1	1	1	2
CO7	3	3	1	3	3	3	2	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 1 (Partially Related)

CO4: 2 (Moderately Related)

CO5: 2 (Moderately Related)

CO6: 1 (Partially Related)

CO7: 3 (Strongly Related)

Justification: CO1 and CO7 directly involve the application of statistical software and probability distributions, which are crucial for disciplinary knowledge in data analysis and statistics. CO2 and CO4, though related to linear algebra, provide foundational skills that can support understanding and manipulating data. CO3 involves advanced linear algebra concepts, which are tangential to statistical analysis.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: All objectives contribute significantly to critical thinking and problem-solving skills required for data analysis. CO1, CO2, CO4, CO5, and CO7 involve analyzing and interpreting data, while CO3 and CO6 involve applying mathematical and simulation techniques to solve problems, all of which require critical thinking.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Social competence involves interpersonal skills and collaboration, which are not directly addressed by the technical objectives of using statistical software, linear algebra, and probability distributions.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: All objectives contribute to research-related skills and scientific temper by involving data analysis, problem-solving, and understanding statistical methods. These skills are essential for conducting research and applying scientific principles in various fields.

PO5. Trans-disciplinary knowledge

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 2 (Moderately Related)

CO7: 3 (Strongly Related)

Justification: The use of statistical software, linear algebra techniques, and probability distributions has applications across different disciplines, making these objectives trans-disciplinary. They provide foundational knowledge and skills applicable in various fields.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 1 (Partially Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 1 (Partially Related)

CO7: 3 (Strongly Related)

Justification: Proficiency in using statistical software, understanding probability distributions, and applying linear algebra concepts enhances personal and professional competence in data analysis, decision-making, and problem-solving, which are valuable skills in various professions.

PO7. Effective Citizenship and Ethics

CO1: 2 (Moderately Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 2 (Moderately Related)

CO6: 1 (Partially Related)

CO7: 2 (Moderately Related)

Justification: While ethical considerations may arise in data analysis and research, the technical skills involved in using statistical software and probability distributions are not directly linked to effective citizenship and ethics.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: The objectives do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 2 (Moderately Related)

CO7: 3 (Strongly Related)

Justification: Using statistical software, understanding probability distributions, and applying linear algebra concepts provide a foundation for self-directed and life-long learning in data analysis and related fields. These objectives enhance students' ability to adapt to new tools and techniques throughout their careers.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. Part – I
Semester	: I
Course Type	:Major Mandatory Practical
Course Name	: Data Science Practical – II
Course Code	: DSC-504-MJM
No. of Credits	: 2
No. of Teaching Hours	: 60

Course Objectives:

1. Develop proficiency in Python programming language and its syntax.
2. Understand the core concepts of object-oriented programming (OOP) and apply them in Python.
3. Gain a solid understanding of Structured Query Language (SQL) and its role in database management.
4. Learn how to write SQL queries to retrieve, modify, and analyze data in relational databases.
5. Apply data wrangling techniques to handle missing values, outliers, and inconsistent data.
6. Understand how to connect Python with SQL databases for data extraction and manipulation.
7. Apply Python and SQL skills to develop end-to-end data science projects.

Course Outcomes:

By the end of the course, students will be able to:

CO1. develop a strong command of Python programming language and its syntax

CO2. apply Python to perform data manipulation, preprocessing, and cleaning tasks.

CO3. demonstrate expertise in writing SQL queries to interact with relational databases.

CO4. apply SQL to retrieve, manipulate, and aggregate data from databases effectively.

CO5. apply Python to preprocess data, train models, evaluate model performance, and perform model selection.

CO6. understand and apply ethical guidelines and principles in data collection, storage, and analysis using Python and SQL

CO7. demonstrate proficiency in using Python libraries and frameworks commonly used in data sciencethink critically to evaluate existing research literature in the field of statistics.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Basics of Python Language, When and why to use Python for Analytics. • Introduction & Installation of Python, Python Syntax, Strings, Lists and Dictionaries
2.	Loops and Regular Expressions
3.	Scientific Libraries in Python • Numpy, Scipy
4.	Introduction to Pandas • Selecting data from Pandas DataFrame, Slicing and dicing using Pandas
5.	Introduction to Pandas • GroupBY / Aggregate, Strings with Pandas, Cleaning up messy data with Pandas, Dropping Entries, Selecting Entries
6.	Data Manipulation using Pandas - I • Data Alignment, Sorting and Ranking, Summary Statistics, Missing values, Merging data
7.	Data Manipulation using Pandas - I • Concatenation, Combining DataFrames, Pivot, Duplicates, Binning
8.	Data visualization on using matplotlib and seaborn libraries • Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot
9.	Control structures using Toyota Corolla dataset •if-else family, for loop, for loop with if break, while loop
10.	Introduction to Database Management System This module introduces you to the database, the need for databases, and their examples. Further, you will learn about Database Management Systems and its history. Lastly, you will go through various Database Management System softwares
11.	Types of Database Management System • This chapter will cover various types of DBMS, including Hierarchical, Network, Relational, and Object-Oriented Databases. You will also be familiarized with several advantages of DBMS.
12.	Introduction to SQL • This chapter will brief you on the introduction to SQL and how to install it on your system. • In this chapter, you will learn how to implement various types of Commands in MySQL, such as DDL, DQL, DML, DCL, and TCL, with hands-on demos.
13.	Filter Record in MySQL • In this chapter, you will learn how to filter the records using the WHERE clause in MySQL, Operation in MySQL
14.	Pattern Matching in MySQL Here, you will learn to find patterns using the LIKE operator with the WHERE clause
	Null Values in MySQL In the final chapter, you will learn to insert a new record or update a record to an optional field without adding a value with the help of a Null value

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	2	3	2	1	3
CO2	2	3	1	3	2	3	2	1	3
CO3	1	2	1	3	2	2	2	1	2
CO4	1	2	1	3	2	2	2	1	2
CO5	2	3	1	3	2	3	2	1	3
CO6	1	3	2	3	2	3	3	1	3
CO7	2	3	2	3	2	3	3	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 2 (Moderately Related)

CO6: 1 (Partially Related)

CO7: 2 (Moderately Related)

Justification: CO1, CO2, and CO5 directly contribute to the development of disciplinary knowledge in data science and programming by focusing on Python programming skills and their application in data manipulation, preprocessing, model training, and evaluation. CO7, although related to statistics, can indirectly enhance disciplinary knowledge by fostering critical evaluation of research literature.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are integral to data science and programming tasks. CO1, CO2, CO5, CO6, and CO7 directly involve applying Python and SQL to solve real-world data problems and evaluate research literature critically, fostering critical thinking skills. CO3 and CO4, although focused on SQL, contribute to problem-solving abilities by enabling effective data retrieval and manipulation.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 2 (Moderately Related)

CO7: 2 (Moderately Related)

Justification: Social competence involves interpersonal skills, collaboration, and ethical considerations in data handling. While CO6 addresses ethical principles in data collection and analysis, other objectives focus primarily on technical skills and are only indirectly related to social competence.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Research-related skills and scientific temper are central to data science tasks. CO1, CO2, CO3, CO4, CO5, CO6, and CO7 directly involve skills and practices essential for conducting research, including data manipulation, analysis, ethical considerations, and critical evaluation of existing literature.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 2 (Moderately Related)

CO6: 2 (Moderately Related)

CO7: 2 (Moderately Related)

Justification: While Python and SQL skills are widely applicable across various disciplines, the specific focus on data science and programming in CO1 to CO7 limits their direct trans-disciplinary relevance. However, these skills can still be valuable in diverse fields requiring data analysis and programming.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Proficiency in Python, SQL, and data science practices enhances personal and professional competence by providing valuable skills for career advancement. CO1, CO2,

CO5, CO6, and CO7 directly contribute to this by focusing on technical expertise, ethical considerations, and critical thinking abilities.

PO7. Effective Citizenship and Ethics

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 2 (Moderately Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO6 directly addresses ethical considerations in data handling, while other objectives indirectly relate to effective citizenship and ethics by promoting responsible data practices and critical evaluation of research literature.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: The objectives primarily focus on technical skills in data science and programming, with limited relevance to environmental or sustainability considerations.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO1 to CO7 equip individuals with skills and practices necessary for self-directed and life-long learning in the field of data science and programming. These objectives focus on technical proficiency, ethical considerations, and critical thinking abilities essential for continuous professional development.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Database Management System
Course Code	: DSC-511-MJE(A)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. Students should gain a solid understanding of the basic concepts and principles of database management systems.
2. Students should learn how to design a relational database, including identifying entities, attributes, and relationships.
3. Students should become proficient in SQL, the standard language for interacting with relational databases.
4. Students should learn techniques for optimizing database queries to improve performance
5. Examine the logical, physical, and database modelling designs.
6. Students should be exposed to emerging trends and technologies in the field of database management systems.
7. Recognize how to create, modify, and query databases for data

Course Outcomes:

By the end of the course, students will be able to:

CO1. be familiar with the fundamentals of database concepts and database management systems.

CO2. understand the fundamental concepts and principles of database management systems, including data models, schemas, instances, and database architecture.

CO3. implement mechanisms for ensuring data integrity, such as primary keys, foreign keys, and constraints.utilize.

CO4. conceptual modelling techniques, like as the ER model and relational model, to model the data requirements for an application.

CO5. Write SQL commands to create tables, insert, update, delete and querying data.

CO6. create and manage database objects, such as tables, views, indexes, and constraints, using SQL.

CO7. normalize a database schema to eliminate redundancy and ensure data integrity.

Topics and Learning Points

Unit 1: **(15L)**

Introduction to file organization &DBMS, Database-system Applications, Purpose of Database Systems, Types of file Organization, File system Vs. DBMS, Data models, Levels of abstraction, Data in dependence, Structure of DBMS, Users of DBMS, Database Architecture, Speciality Databases.

Unit 2: **(15L)**

Structure of Relational Databases, Database Schema, Keys, Relational Operations, Conceptual Design (E-R model), Overview of DB design, ER data model (entities, attributes, entity sets, relations, relationship sets),Additional constraints (Key constraints, Mapping constraints), Conceptual design using ER modelling. Relational data model, Conversion of ER to Relational model, Integrity constraints, Relational algebra, Preliminaries.

Unit 3:(15L)

Introduction to SQL, Basic structure, Set operations, Aggregate functions, Null values , PL/PgSqL: Data types, Language structure, Operations with SQL, Nested Sub queries, Modifications to Database, DDL and DML commands with examples, SQL mechanisms for joining.

Unit 4 : **(15L)**

Intermediate and advanced SQL: Join Expressions- Join conditions, Outer joins, Join types and conditions, Views- View definition, using views in SQL queries, Materialized views, update a view 4.3 Create table extensions, Schemas, Catalogs and Environments, The relational Algebra, The tuple relational calculus.

References:

1. Abraham Silberschatz, Henry F. Korth, S. Sudarashan, Database System Concepts, McGraw-Hill International Edition, Sixth Edition
2. Elmasri, Navathe, Fundamentals of Database Systems, Pearson Education, Third Education
3. Ramakrishnan, Gehrke, Database Management Systems, McGraw Hill International Edition, Third Edition
4. Peter Rob, Carlos Coronel, Database System Concepts, Cengage Learning, India Edition
5. S.K. Singh, “Database Systems Concepts, Design and Applications”, First Edition, Pearson Education, 2006
6. Redmond, E. & Wilson, Seven Databases in Seven Weeks: A Guide to Modern Databases and the No SQL Movement Edition:1st Edition.

7. Shamkant B. Navathe, RamezElmasri,(2010), Database Systems, ISBN:9780132144988, PEARSON HIGHER EDUCATION
8. Richard Stones, Neil Matthew, (2005), Beginning Databases with PostgreSQL: From Novice to Professional, ISBN:9781590594780, Apress
9. Korry, Douglas, (2005), Postgre SQL, ISBN:9780672327568, Sams Publishing.
10. Joshua D. Drake, John C. Worsley, Practical Postgre SQL, (2002), ISBN:9788173663925 O'Reilly Media, Inc., ISBN: 9781565928466.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	2	2	1	2	2	3	1	1	3
CO2	3	3	1	2	2	3	1	1	3
CO3	3	3	1	3	2	3	2	1	3
CO4	3	3	1	3	3	3	2	1	3
CO5	3	3	1	3	3	3	2	1	3
CO6	3	3	1	3	3	3	2	1	3
CO7	3	3	1	3	3	3	2	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 2 (Moderately Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Database management systems (DBMS) are foundational to the field of information technology and computer science. CO1 through CO7 provide a comprehensive

understanding of database concepts and management, directly contributing to disciplinary knowledge in this area.

PO2. Critical Thinking and Problem solving

CO1: 2 (Moderately Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are essential for designing and managing databases effectively. CO2 through CO7 require students to analyze data requirements, design appropriate database structures, and implement solutions using SQL commands, thus fostering critical thinking skills.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Database management skills are more technical and less directly related to social competence, which involves interpersonal skills and collaboration.

PO4. Research-related skills and Scientific temper

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO1 through CO7 involve applying structured methods and techniques to organize, manage, and retrieve data effectively, which are fundamental research-related skills. Additionally, understanding database concepts contributes to fostering a scientific temper by promoting systematic and methodical approaches to data management and analysis.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Database management skills are applicable across various disciplines and industries. CO1 through CO7 provide knowledge and skills that can be applied in diverse contexts, contributing to trans-disciplinary knowledge.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Proficiency in database management is highly valued in professional settings. CO1 through CO7 equip students with essential skills and knowledge for managing data effectively, enhancing personal and professional competence.

PO7. Effective Citizenship and Ethics

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 2 (Moderately Related)

CO6: 2 (Moderately Related)

CO7: 2 (Moderately Related)

Justification: While ethical considerations may arise in data management practices, the technical skills involved in CO1 through CO7 are not directly related to effective citizenship and ethics.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Database management skills do not directly address environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Database management skills are foundational and continuously evolving. CO1 through CO7 provide students with a solid foundation and the necessary skills for self-directed and life-long learning in this field.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Major Elective Theory
Course Name	: Stochastic Models and Applications
Course Code	: DSC-511-MJE(B)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. students should acquire a fundamental understanding of stochastic processes, including the definition, types, and basic properties.
2. to understand discrete and continuous Markov chains models to compute the probability of events.
3. formulate and solve problems by computing the long-term probabilities of a Markov chain model.
4. write Python/R code to simulate Markov chains, and compute probabilities of events that may be difficult to derive by hand.
5. apply Poisson processes to model the occurrence of events in various applications.
6. students understand the practical relevance and utility of stochastic processes in modeling and analyzing complex systems.
7. students should learn about the properties of Markov chains, including the Markov property, transition probabilities, stationary distributions, and ergodicity.

Course Outcomes:

By the end of the course, students will be able to:

CO1. perform calculations involving transition probabilities, steady-state distributions, and inter-arrival times for Markov chains and Poisson processes.

CO2. explain the fundamental principles of probability theory and random variables as they pertain to stochastic processes.

CO3. present findings and results of stochastic process analyses in a clear and organized manner.

CO4. use simulation methods and computational tools to model and analyze stochastic

processes.

CO5. evaluate the appropriateness of different stochastic process models for specific applications and contexts.

CO6. to familiar with stochastic processes, including Poisson process, Wiener process and Renewal process, etc.

CO7. demonstrate the ability to independently research and explore advanced topics related to stochastic processes

Topics and Learning Points

Unit1: **(15L)**

Notion of stochastic processes, Markov chain, one step transition probabilities, Chapman-Kolmogorov equations, evaluation of higher step transition probabilities, classification of states, periodicity of a Markov chain, concept of closed class, minimal closed class, stationary distribution. Some examples such as gamblers ruin problem and one-dimensional random walk. Concept of absorption probabilities, Use of these to compute probability of winning the game by a gambler having initial capital 'a'

Unit2: **(15L)**

Branching process, classification of states, identification of criticality parameter, extinction probability, relationship between criticality parameter and extinction probability of the process, Expression for mean and variance of the process. Extinction probability, Some epidemiological applications, Introduction to Markov chain in continuous time, concept of intensity rate, relationship between intensity matrix and transition probability matrix. Kolmogorov's forward and backward equations

Unit3: **(15L)**

Introduction to birth process, birth and death process, linear birth and death process, Growth model with immigration and related results, Expression for mean and variance of a birth process and, birth and death process, Applications of these processes.

Unit4: **(15L)**

i) Poisson process, two definitions and their equivalence, Distribution of inter arrival times, conditional joint distribution of inter arrival times. Compound Poisson process,

Some applications. Introduction to renewal process, relationship with Poisson process, key and elementary renewal theorems associated with renewal processes.

References:

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4. Ross, S. (2014). Introduction to Probability Models, 11th Edn. Academic Press.
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6. Hoel, P.G. Port, S.C. & Stone, C.J. (1972). Introduction to Stochastic Processes, Houghton Mifflin
7. Karlin, S & Taylor, H.M. (1975). A First Course in Stochastic Processes (Second. Edition), Academic Press.
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Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)								
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	1	3	3	3	1	1	3
CO2	3	3	1	3	3	3	1	1	3
CO3	2	3	2	3	2	2	1	1	3
CO4	2	3	1	3	2	2	1	1	3
CO5	2	3	1	3	3	3	1	1	3
CO6	3	3	1	3	3	3	1	1	3
CO7	3	3	1	3	3	3	1	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 2 (Moderately Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: The objectives outlined in CO1, CO2, CO6, and CO7 directly contribute to disciplinary knowledge in stochastic processes by covering fundamental principles, calculations, and advanced topics related to the field. CO3 and CO4, while not directly related to stochastic processes, still enhance disciplinary knowledge by emphasizing clear presentation and the use of computational tools.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are essential for understanding and analyzing stochastic processes. All objectives (CO1 to CO7) directly involve critical thinking and problem-solving skills, as they require students to analyze complex probabilistic systems, evaluate models, and apply appropriate methods for analysis and simulation.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 2 (Moderately Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Social competence, focusing on interpersonal skills and collaboration, is not directly addressed by the technical objectives of stochastic processes.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Research-related skills and scientific temper are central to stochastic processes, as they involve the analysis and modeling of uncertain systems. All objectives (CO1 to CO7) directly contribute to research-related skills by involving analysis, presentation, and exploration of advanced topics.

PO5. Trans-disciplinary knowledge

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Stochastic processes have applications in various fields such as engineering, finance, and biology. Therefore, understanding stochastic processes contributes to trans-disciplinary knowledge. CO1, CO2, CO5, CO6, and CO7 directly involve the application of stochastic processes in various contexts, enhancing trans-disciplinary understanding.

PO6. Personal and professional competence

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Personal and professional competence are enhanced through the mastery of stochastic processes, as it provides valuable skills for decision-making and problem-solving in various professional contexts. All objectives (CO1 to CO7) contribute to personal and professional competence by developing expertise in stochastic modeling and analysis.

PO7. Effective Citizenship and Ethics

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Effective citizenship and ethics are not directly addressed by the technical objectives of stochastic processes.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: Stochastic processes are not directly related to environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Stochastic processes require continuous learning and adaptation to new methodologies and applications. All objectives (CO1 to CO7) directly contribute to self-directed and life-long learning by providing a foundation for understanding and exploring advanced topics in stochastic processes.

CBCS Syllabus as per NEP 2020 for M.Sc. Part-I Data Science (2023 Pattern)

Name of the Programme	: M.Sc. Data Science
Program Code	: PSDSC
Class	: M.Sc. (Part – I)
Semester	: I
Course Type	: Research Methodology
Course Name	: Research Methodology
Course Code	: DSC-521-RM
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To introduce the statistical aspects associated with the design and analysis of sample surveys, and to develop your understanding of the principles and methods used to design survey sampling schemes.
2. Understand the steps in developing a sampling plan.
3. Distinguish between probability and non-probability sampling.
4. Develop critical thinking on sampling methods and results.
5. Understand potential sources of error and limitations of different sampling techniques.
6. To introduce the fundamental concepts and principles of research, including the scientific method, research questions and research designs.
7. To develop skills in designing research studies, including formulating research questions, selecting appropriate research designs.
8. To develop critical thinking to evaluate research studies, methodologies, and findings.

Course Outcomes:

By the end of the course, students will be able to:

CO1. define principal concepts about sampling.

CO2. lists the stages of sampling process.

CO3. understand the distinctive features of different sampling techniques and their related estimation problems.

CO4. learn the practical applications of the various sampling techniques in real life situations.

CO5. develop an appreciation for research ethics and demonstrate an understanding of ethical principles and guidelines in conducting research.

CO6. apply appropriate research design principles to formulate research questions.

CO7. develop research proposals that demonstrate clear research objectives, appropriate methodologies, and justifications for the significance of the research.

Topics and Learning Points

Unit – 1 **(15L)**

Meaning of research, objectives of research, motivation in research, types of research, research approaches, significance of research, overview of research methods in data science, defining the research problem, designing a questionnaire

Unit – 2 **(18L)**

Data collection methods: Primary, secondary data collection methods, introduction to sampling techniques, finite population techniques SRSWR, SRSWOR, stratified sampling, systematic sampling, clustering , probability proportional to size with replacement(PPSWR) methods, Non probability sampling techniques, sample size determination

Unit – 3 **(10L)**

Data pre-processing and cleaning, data pre-processing technique (missing values, imputation, outlier detection and treatment, data transformation), cleaning and preparing data set for analysis

Unit – 4 **(15L)**

Layout of the research report, types of reports, construction of title and preparation of abstract for research paper / proposed project, writing of materials and methods, results discussions, conclusion etc., writing of research proposals, significance of report writing, different steps in writing report, oral presentation,mechanics of writing research report, precautions for writing research reports, research ethics. Use of tools or techniques for research: methods to search required information effectively,reference management software like Zotero/ Mendeley, software for paper formatting like LaTex/ MS office, software for detection of plagiarism.

References:

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2. Murthy M.N.(1977) Sampling theory and methods. (Statistical Publishing Society)
3. ParimalMukhopadhyay, Theory and methods of survey sampling, Prentice Hall of

India private limited, 2nd Edition, 2008.

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5. Sukhatme P.V. Sukhatme B.V. and C. Ashok Sampling theory of surveyand applications.(Indian society for Agricultural statistics)
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10. Research Methodology ;Panneerselvam R., PHI, Learning Pvt. Ltd., New Delhi – 2009.

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Course Outcomes	Programme Outcomes (POs)								
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CO2	2	3	1	3	2	1	2	1	2
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CO4	3	3	1	3	2	1	2	1	2
CO5	1	2	3	3	3	3	3	1	3
CO6	1	2	3	3	3	3	3	1	3
CO7	1	3	3	3	3	3	3	1	3

Weight: 1 - Partially related 2 - Moderately Related 3 - Strongly related

PO1. Disciplinary Knowledge

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: CO1, CO3, and CO4 directly pertain to the disciplinary knowledge of sampling techniques and estimation problems. CO2 is moderately related as it involves understanding the process of sampling, which is a foundational aspect but not directly related to specific techniques. CO5, CO6, and CO7 are only partially related as they focus more on research ethics, design principles, and proposal development rather than the technical aspects of sampling.

PO2. Critical Thinking and Problem solving

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 2 (Moderately Related)

CO6: 2 (Moderately Related)

CO7: 3 (Strongly Related)

Justification: Critical thinking and problem-solving skills are essential in understanding and applying sampling techniques and research methodologies. CO1, CO2, CO3, and CO4 directly involve performing calculations, understanding stages of sampling, distinguishing between techniques, and applying them to real-life situations. CO5, CO6, and CO7 contribute moderately by addressing research ethics, design principles, and proposal development.

PO3. Social competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: While CO5, CO6, and CO7 focus on research ethics, design principles, and proposal development, they indirectly contribute to social competence by fostering an understanding of ethical conduct in research and effective communication of research objectives and methodologies.

PO4. Research-related skills and Scientific temper

CO1: 3 (Strongly Related)

CO2: 3 (Strongly Related)

CO3: 3 (Strongly Related)

CO4: 3 (Strongly Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: Research-related skills and scientific temper are directly addressed by all objectives. CO1 to CO4 involve technical aspects of sampling and research methodologies, while CO5 to CO7 focus on research ethics, design principles, and proposal development, collectively fostering a research-oriented mindset.

PO5. Trans-disciplinary knowledge

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: While sampling techniques and research methodologies have applications across various disciplines, CO1 to CO4 are more directly related to the technical aspects, while CO5 to CO7 are more broadly applicable across disciplines, focusing on research ethics, design principles, and proposal development.

PO6. Personal and professional competence

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: While the technical aspects of sampling and research methodologies (CO1 to CO4) are only partially related to personal and professional competence, CO5 to CO7, focusing on research ethics, design principles, and proposal development, directly contribute to enhancing professional competence.

PO7. Effective Citizenship and Ethics

CO1: 2 (Moderately Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: CO5 to CO7 directly address ethical principles and guidelines in research, contributing to effective citizenship and ethical conduct in academic and professional settings.

PO8. Environment and Sustainability

CO1: 1 (Partially Related)

CO2: 1 (Partially Related)

CO3: 1 (Partially Related)

CO4: 1 (Partially Related)

CO5: 1 (Partially Related)

CO6: 1 (Partially Related)

CO7: 1 (Partially Related)

Justification: The objectives do not directly relate to environmental or sustainability concerns.

PO9. Self-directed and Life-long learning

CO1: 3 (Strongly Related)

CO2: 2 (Moderately Related)

CO3: 2 (Moderately Related)

CO4: 2 (Moderately Related)

CO5: 3 (Strongly Related)

CO6: 3 (Strongly Related)

CO7: 3 (Strongly Related)

Justification: The objectives promote self-directed and life-long learning by providing skills and knowledge essential for conducting research and developing research proposals. CO1, CO5, CO6, and CO7 are particularly relevant as they involve technical aspects of research and proposal development.