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 – II

For Department of Statistics

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2024-2025

Program Outcomes for M.Sc.

PO1. Comprehensive Knowledge and Understanding:

Postgraduates will possess a profound understanding of their field, encompassing foundational theories, methodologies, and key concepts within a multidisciplinary context.

PO2. Practical, Professional, and Procedural Knowledge:

Postgraduates will acquire practical skills and expertise necessary for professional tasks, including industry standards, regulations, and ethical considerations, with effective application in real-world scenarios.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:

Postgraduates will cultivate an entrepreneurial mindset, identify opportunities, foster innovation, and understand business principles, market dynamics, and risk management strategies.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:

Postgraduates will demonstrate proficiency in technical skills, analytical abilities, effective communication, and leadership, adapting and innovating in response to changing circumstances.

PO5. Research, Analytical Reasoning, and Ethical Conduct:

Postgraduates will exhibit observational and inquiry skills, formulate research questions, utilize appropriate methodologies for data analysis, and adhere to research ethics while effectively reporting findings.

PO6. Communication, Collaboration, and Leadership:

Postgraduates will effectively communicate complex information, collaborate in diverse teams, demonstrate leadership qualities, and facilitate cooperative efforts toward common goals.

PO7. Digital Proficiency and Technological Skills:

Postgraduates will demonstrate proficiency in using ICT, accessing information sources, analyzing data using appropriate software, and adapting to technological advancements.

PO8. Multicultural Competence, Inclusive Spirit, and Empathy:

Postgraduates will engage effectively in multicultural settings, respect diverse perspectives, lead diverse teams, and demonstrate empathy and understanding of others' perspectives and emotions.

PO9. Value Inculcation, Environmental Awareness, and Ethical Practices:

Postgraduates will embrace ethical and moral values, practice responsible citizenship, recognize and address ethical issues, and promote sustainability and environmental conservation.

PO10. Autonomy, Responsibility, and Accountability:

Postgraduates will apply knowledge and skills independently, manage projects effectively, and demonstrate responsibility and accountability in work and learning contexts, contributing to societal well-being.

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. Rohan Koshti	Expert from other University
14.	Mr. Saurabh Kadam	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. Rushikesh Pandhare (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 Distributions (Credit 04) DSC-502-MJM: Statistical Inference (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: Design and Analysis of Experiments (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**	

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

Level	Semester	Major		Research Methodology (RM)	OJT /FP	RP	Cum. Cr.	Degree
		Mandatory	Electives					
6.5	Sem-III	DSC-601-MJM: Exploratory Multivariate Data Analysis (Credit 04)	DSC-611-MJE(A): Machine Learning (Credit 02)	--	--	DSC-621-RP: Research Project (Credit 04)	**20**	PG Diploma (after 3 Year Degree)
		DSC-602-MJM: Time Series Analysis and Forecasting (Credit 04)	DSC-611-MJE(B): Text Mining and Natural Language Processing (Credit 02)					
		DSC-503-MJM: Statistics Practical – V (Credit 02)	DSC-612-MJE(A): Machine Learning: Techniques and Applications (Credit 02)					
		DSC-504-MJM: Statistics Practical – VI (Credit 02)	DSC-612-MJE(B): Practical Based on Text Mining and NLP (Credit 02)					
	Sem-IV	DSC-651-MJM: Artificial Intelligence (Credit 04)	DSC-661-MJE (A): Supply Chain and Logistics Analytics (Credit 02)	--	--	DSC-621-RP: Research Project (Credit 06)	**20**	
		DSC-652-MJM: Deep Learning (Credit 04)	DSC-661-MJE(B): Discrete Data Analysis (Credit 02)					
		DSC-653-MJM: Data Science Practical – VI (Credit 02)	DSC-662-MJE (A): Introduction to Hadoop (Credit 02)					
			DSC-662-MJE (A): Web Application Development (Credit 02)					

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

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
I	Major (Mandatory)	DSC-501-MJM	Probability Distributions	Theory	04
	Major (Mandatory)	DSC -502-MJM	Statistical Inference	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	Design and Analysis of Experiments	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**

Course Structure for M.Sc. Part-II (Data Science) (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	No. of Credits
III	Major (Mandatory)	DSC-601-MJM	Exploratory Multivariate Data Analysis	Theory	04
	Major (Mandatory)	DSC -602-MJM	Time Series Analysis and Forecasting	Theory	04
	Major (Mandatory)	DSC -603-MJM	Data Science Practical – V	Practical	02
	Major (Mandatory)	DSC -604-MJM	Data Science Practical – VI	Practical	02
	Major (Elective)	DSC-611-MJE(A)	Machine Learning	Theory	02
		DSC -611-MJE(B)	Text Mining and Natural Language Processing	Theory	
		DSC-612-MJE (A)	Machine Learning: Techniques and Applications	Practical	02
		DSC -612-MJE (B)	Practical Based on Text Mining and NLP	Practical	
	Research Project (RP)	DSC -621-RP	Research Project	Project	04
				Total Credits Semester III	**20**
IV	Major (Mandatory)	DSC -651-MJM	Artificial Intelligence	Theory	04
	Major (Mandatory)	DSC-652-MJM	Deep Learning	Theory	04
	Major (Mandatory)	DSC-653-MJM	Data Science Practical – VI	Practical	02
	Major (Elective)	DSC -661-MJE (A)	Supply Chain and Logistics Analytics	Theory	02
		DSC -661-MJE (B)	Discrete Data Analysis	Theory	
		DSC -662-MJE (A)	Introduction to Hadoop	Practical	02
		DSC -662-MJE (B)	Web Application Development	Practical	
	Research Project (RP)	DSC -581-RP	Research Project	Project	06
				Total Credits Semester-IV	**20**
				Cumulative Credits Semester III and IV	**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	: II
Course Type	: Major Mandatory Theory
Course Name	: Design and Analysis of Experiments
Course Code	: DSC-551-MJM
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To understand the concept of GLM.
2. To use various design properly to various purpose.
3. To carry out Experimental techniques and methods efficiently and effectively.
4. To make interpretations by using design of experiments.
5. To learn and understand various designs of experiments.
6. To design and carryout various experiments and analyze the data.
7. To apply appropriate design in real life situation.

Course Outcomes:

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

CO1 learn and understand concept of general linear mode;

CO2 understand the properties of general linear model.

CO3 learn and understand various designs of experiments.

CO4 design and carryout various experiments and analyze the data.

CO5 apply appropriate design in real life situation.

CO6 apply Factorial design, fractional factorial design, confounding in real life problems

CO7 Apply advanced techniques of Design of experiments like Taguchi method, etc.

Topics and Learning Points

Unit 1 **(15 L)**

Analysis of one-way classification modal. Analysis of two-way classification model with equal number of observations per cell with and without interactions. Analysis of two-

way classification model with unequal number of observations per cell without interactions. Introduction of the Design of Experiments (DOE), The Basic Principles of DOE, Steps for Planning, Conducting and Analysing an Experiment, Principles of scientific experimentation – Basic Designs: Completely Randomized Design (CRD), Randomized Block Design (RBD) and Latin Square Design (LSD) – Analysis of RBD (with one observation per cell, more than one but equal number of observations per cell).

Unit 2 **(5 L)**

Multiple Comparisons, Multiple Range Tests, Statistical analysis of Covariance. Analysis of non- normal data using: square root transformation for counts, $Sin^{-1}(.)$ transformation for proportions, Kruskal Wallis test.

Unit 3 **(15 L)**

Full Factorial experiments and their analysis, concepts of main effects, interaction effect, their graphical representation, analysis of single replicate and more than one replicates of 2^kdesignand partial confounding of 2^k,fractional experiments in 2^k. Statistical analysis of single replicate and more than one replicates of 3^kdesign, confounding and fractional experiments in 3^k.

Unit 4 **(15 L)**

Balanced Incomplete Block Design (BIBD) – Types of BIBD – Simple construction methods Concept of connectedness and balancing – Intra Block analysis of BIBD. Partially Balanced Incomplete Block Design with two associate classes – intra block analysis. Split plot and strip plot design and their analysis.

Unit 5 **(10 L)**

Response surface methodology (RSM): linear and quadratic model, stationary point, central composite designs(CCD), ridge systems, multiple responses, concept of rotatable designs, Box-Behnken design, optimality of designs, simplex lattice designs, simplex centroid designs.

References:

1. Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer.
2. George E. P. Box, Draper N.R. (1987). Empirical Model-Building and Response Surfaces, Wiley.
3. Kshirsagar A.M. (1983). Linear Models, Marcel Dekker.

4. Montgomery, D.C. (2001). Design and Analysis of Experiments, Wiley.
5. Phadke, M.S. (1989). Quality Engineering using Robust Design, Prentice Hall,Englewood Cliffs, New Jersey.
6. Wu, C.F. Jeff and Hamada M. (2000). Experiments: Planning, Analysis and Parameter Design Optimization, John Wiley and Sons.
7. Bapat, R. B. (2012). Linear algebra and linear models. Springer Science & Business.

Programme Outcomes and Course Outcomes Mapping:

	Programme Outcomes(POs)									
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
CO1	3	2	2	3	2	2	3	1	1	1
CO2	2	3	1	3	2	2	3	1	1	1
CO3	2	2	2	3	2	2	3	1	1	1
CO4	2	3	2	3	2	2	3	1	1	1
CO5	2	3	2	3	2	2	3	1	1	1
CO6	2	3	2	3	2	2	2	1	1	1
CO7	2	3	2	3	2	2	3	1	1	1

PO1. Comprehensive Knowledge and Understanding:

CO1: Strongly Related (Weightage: 3)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

Justification: PO1 focuses on acquiring a broad and deep understanding of various concepts. CO1 is strongly related as it directly addresses understanding the general linear model. CO2 to CO7 are moderately related as they contribute to understanding experimental designs, data analysis techniques, and applying statistical methods, all of which enrich the comprehensive knowledge and understanding in the field.

PO2. Practical, Professional, and Procedural Knowledge:

CO1: Moderately Related (Weightage: 2)

CO2: Strongly Related (Weightage: 3)

CO3: Moderately Related (Weightage: 2)

CO4: Strongly Related (Weightage: 3)

CO5: Strongly Related (Weightage: 3)

CO6: Strongly Related (Weightage: 3)

CO7: Strongly Related (Weightage: 3)

Justification: PO2 involves acquiring practical, professional, and procedural knowledge. All the objectives (CO1 to CO7) are strongly related as they contribute directly to practical skills, understanding procedures, and professional competence in experimental design, data analysis, and statistical modeling.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:

CO1: Moderately Related (Weightage: 2)

CO2: Partially Related (Weightage: 1)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

Justification: While aspects of innovation and business understanding may not be directly addressed by these objectives, understanding experimental designs and data analysis techniques (CO3 to CO7) can contribute indirectly to fostering an entrepreneurial mindset by enabling the identification of opportunities and problem-solving skills.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: Strongly Related (Weightage: 3)

CO2: Strongly Related (Weightage: 3)

CO3: Strongly Related (Weightage: 3)

CO4: Strongly Related (Weightage: 3)

CO5: Strongly Related (Weightage: 3)

CO6: Strongly Related (Weightage: 3)

CO7: Strongly Related (Weightage: 3)

Justification: PO4 focuses on specialized skills, critical thinking, and problem-solving abilities. All objectives (CO1 to CO7) are strongly related as they directly contribute to developing these skills through understanding statistical models, experimental designs, and applying advanced techniques in data analysis.

PO5. Research, Analytical Reasoning, and Ethical Conduct:

CO1: Moderately Related (Weightage: 2)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

Justification: PO5 encompasses research skills, analytical reasoning, and ethical conduct. While CO1 to CO7 contribute to analytical reasoning and research skills, they are only moderately related to ethical conduct, as ethical considerations are not explicitly addressed within these objectives.

PO6. Communication, Collaboration, and Leadership:

CO1: Moderately Related (Weightage: 2)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

Justification: While these objectives mainly focus on technical skills, understanding experimental designs and data analysis techniques (CO1 to CO7) can indirectly contribute to communication, collaboration, and leadership skills by facilitating effective problem-solving and decision-making processes.

PO7. Digital Proficiency and Technological Skills:

CO1: Moderately Related (Weightage: 2)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Strongly Related (Weightage: 3)

Justification: PO7 focuses on digital proficiency and technological skills. While all objectives (CO1 to CO7) involve the application of statistical methods using software tools like R, CO7 is particularly strong in this aspect as it involves applying advanced techniques of experimental design using technology

PO8. Multicultural Competence, Inclusive Spirit, and Empathy:

All COs: Partially Related (Weightage: 1)

Justification: None of the objectives directly relate to multicultural competence, inclusive spirit, or empathy. These aspects are not explicitly addressed within the context of statistical modeling and experimental design.

PO9. Value Inculcation, Environmental Awareness, and Ethical Practices:

- All COs: Partially Related (Weightage: 1)

Justification: While ethical practices are indirectly involved in conducting experiments and data analysis, none of the objectives explicitly address environmental awareness or value inculcation.

PO10. Autonomy, Responsibility, and Accountability:

All COs: Partially Related (Weightage: 1)

Justification: While the objectives involve developing skills and knowledge, they do not directly address autonomy, responsibility, or accountability. These aspects are more related to personal and professional development, which may be indirectly fostered through achieving the objectives.

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	: II
Course Type	: Major Mandatory Theory
Course Name	: Regression Analysis and Predictive Models
Course Code	: DSC-552-MJM
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To provide a comprehensive understanding of the fundamental concepts of regression analysis.
2. To explain the importance of regression in statistical modeling and its applications in various fields.
3. To interpret and communicate the results of simple linear regression models.
4. Enable students to use multiple linear regression for practical problem-solving.
5. Explain the importance of residual analysis in assessing model adequacy.
6. Discuss when and how to apply these models to capture more complex relationships in data.
7. To provide an overview of Generalized Linear Models (GLM) and their significance in statistical analysis.

Course Outcomes:

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

CO 1. Deep comprehension of the linear and nonlinear regression models.

CO 2. Demonstrate understanding of model selection and regression modeling approaches.

CO 3. The connections between dependent and independent variables should be examined.

CO 4. Estimate the parameters and fit a model.

CO 5. Investigate possible diagnostics in regression modeling and analysis.

CO 6. Validate the model using hypothesis testing and confidence interval approach.

CO 7. Understanding advanced regression techniques, such as logistic regression for binary outcomes or Poisson regression for count data.

Topics and Learning Points

Unit 1 **(10 L)**

Simple Linear Regression Analysis:

Simple linear regression model, Ordinary Least Square method, generalized and weighted least squares, validating simple regression model using t, F test, developing confidence interval.

Unit 2 **(15 L)**

Multiple linear Regression Analysis

Concept of Multiple regression model, Ordinary Least Square method, generalized and weighted least squares, Assessing the fit of the regression line, inferences from multiple regression analysis, problem of over fitting of a model, comparing two regression model, prediction with multiple regression equation.

Unit 3 **(18 L)**

Model Adequacy Checking and Transformation Techniques:

Residual analysis, PRESS statistics, detection and treatment of outliers, lack of fit of the regression model, test of lack of fit, Problem of autocorrelation and heteroscedasticity. Variance stabilizing transformations, transformations to linearize the model, Box-Cox methods, transformations on the repressors variables. Multicolinearity, sources of multicollinearity, effects of multicollinearity. Multicollinearity diagnostics: examination of correlation matrix, variance Inflation factors (VIF), Eigen system analysis of X'X. Methods of dealing with Multicollinearity:

Unit 4 **(17 L)**

Polynomial regression, Non-linear regression:

Non-linear least squares transformation to a linear model, their uses and limitations, examination of non-linearity, initial estimates, iterative procedure, Newton-Raphson method. Generalized linear model: Link function: normal, binomial, Poisson, exponential, gamma.

Logistic regression: Logit transform, ML estimation, tests of hypothesis, Wald test, LR test, score test, test for overall regression.

References:

1. Draper, N. R. and Smith H. (1998) Applied regression analysis 3rd edition (John Wiley)
2. Hosmer, D. W. and Lemeshow, S. (1989) Applied logistic regression (John Wiley)
3. McCullagh, P. and Nelder, J. A.(1989) Generalized linear models (Chapman and Hall)
4. Montogomery D. C., Elizabeth a. Peck, G. Geoffrey.(2003) Introduction to linear regression analysis (Wiley Eastern)
5. Neter, J.; Wasserman, W. and Kutner, M.H.(1985) Applied linear statistical models
6. Ratkowsky, D. A.(1983) Nonlinear regression modeling (Marcel Dekker)

Programme Outcomes and Course Outcomes Mapping:

	Programme Outcomes(POs)									
Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10
CO1	3	3								
CO2	3	3								
CO3	3	3								
CO4	3	3								
CO5	3	3								
CO6	3	3								
CO7	3	3								

PO 1 Comprehensive Knowledge and Understanding:

CO 1: Weightage = 3 (Strongly Related)

Justification: Understanding regression models is foundational knowledge in data analysis and statistics, which aligns directly with the requirement for postgraduates to possess profound understanding of foundational theories and methodologies in their field.

CO 2: Weightage = 3 (Strongly Related)

Justification: Model selection and regression modeling approaches are fundamental concepts in statistical analysis, which contribute to the multidisciplinary understanding required by postgraduates in their field.

CO 3: Weightage = 3 (Strongly Related)

Justification: Examining the connections between dependent and independent variables is essential in regression analysis and contributes to a profound understanding of foundational theories and methodologies in the field.

CO 4: Weightage = 3 (Strongly Related)

Justification: Parameter estimation and model fitting are core components of regression analysis, directly aligning with the requirement for postgraduates to possess a profound understanding of methodologies within their field.

CO 5: Weightage = 3 (Strongly Related)

Justification: Diagnostic analysis in regression modeling is crucial for assessing model validity and reliability, contributing to the postgraduates' ability to effectively apply methodologies in real-world scenarios.

CO 6: Weightage = 3 (Strongly Related)

Justification: Model validation through hypothesis testing and confidence intervals demonstrates the postgraduates' ability to apply statistical techniques effectively, contributing to their practical skills and expertise necessary for professional tasks.

CO 7: Weightage = 3 (Strongly Related)

Justification: Knowledge of advanced regression techniques expands postgraduates' understanding of methodologies in their field, aligning with the requirement for a profound understanding of foundational theories and concepts within a multidisciplinary context.

PO 2 Practical, Professional, and Procedural Knowledge:

CO 1: Weightage = 3 (Strongly Related)

Justification: Practical knowledge of regression models is crucial for professionals in various fields such as economics, engineering, and social sciences. Understanding regression models aligns directly with acquiring practical skills necessary for professional tasks.

CO 2: Weightage = 3 (Strongly Related)

Justification: Being able to select appropriate models and approaches is a practical skill required for professional tasks in data analysis and decision-making. Understanding regression modeling approaches contributes directly to practical, professional knowledge.

CO 3: Weightage = 3 (Strongly Related)

Justification: Examining connections between variables is essential for making informed decisions in professional settings. Understanding these connections contributes directly to practical knowledge and expertise.

CO 4: Weightage = 3 (Strongly Related)

Justification: Estimating parameters and fitting models are practical tasks required for various professional applications, such as forecasting, risk assessment, and policy analysis.

CO 5: Weightage = 3 (Strongly Related)

Justification: Diagnostics in regression modeling are essential for ensuring the reliability and validity of results in practical applications. Postgraduates need to be adept at investigating diagnostics to make informed decisions in real-world scenarios.

CO 6: Weightage = 3 (Strongly Related)

Justification: Validating models through hypothesis testing and confidence intervals is crucial for ensuring the robustness of findings in practical applications. This directly contributes to acquiring practical, professional knowledge.

CO 7: Weightage = 3 (Strongly Related)

Justification: Advanced regression techniques are often used in professional settings to address complex problems. Understanding these techniques enhances postgraduates' practical skills and expertise, aligning with the acquisition of practical, professional knowledge.

PO 3 Entrepreneurial Mindset, Innovation, and Business Understanding:

CO 1: Weightage = 1 (Partially Related)

Justification: While understanding regression models may indirectly support innovation and business understanding by providing tools for data analysis, it is not directly linked to cultivating an entrepreneurial mindset or understanding business principles.

CO 2: Weightage = 2 (Moderately Related)

Justification: Understanding model selection and regression approaches can indirectly contribute to fostering innovation by providing the skills to analyze and interpret data effectively, which can aid in identifying business opportunities.

CO 3: Weightage = 2 (Moderately Related)

Justification: Examining connections between variables is crucial for understanding the factors influencing business outcomes, thus contributing to business understanding and potentially fostering innovation.

CO 4: Weightage = 2 (Moderately Related)

Justification: Parameter estimation and model fitting can provide insights into relationships between variables, aiding in understanding business dynamics and potentially identifying opportunities for innovation.

CO 5: Weightage = 1 (Partially Related)

Justification: While diagnostics are important for ensuring the validity of regression models, they may not directly contribute to entrepreneurial mindset cultivation or business understanding.

CO 6: Weightage = 1 (Partially Related)

Justification: Model validation techniques are essential for ensuring the reliability of findings but may not directly align with entrepreneurial mindset cultivation or business understanding.

CO 7: Weightage = 1 (Partially Related)

Justification: While advanced regression techniques may have applications in certain business contexts, they are not directly tied to cultivating an entrepreneurial mindset or understanding business principles.

PO 4: Specialized Skills, Critical Thinking, and Problem-Solving

CO1: Weightage: 3 (Strongly Related)

Justification: Proficiency in regression modeling is crucial for developing technical skills and analytical abilities, aligning with the objective of specialized skills and problem-solving.

CO2:. Weightage: 3 (Strongly Related)

Justification: Understanding model selection methods enhances critical thinking by enabling postgraduates to choose appropriate regression techniques for different scenarios, supporting the objective of specialized skills and problem-solving.

CO3:. Weightage: 2 (Moderately Related)

Justification: Analysing the connections between variables requires critical thinking and contributes to problem-solving abilities, although it may not directly align with all aspects of technical proficiency and effective communication.

PO 5: Research, Analytical Reasoning, and Ethical Conduct

CO4: Weightage: 2 (Moderately Related)

Justification: Estimating model parameters and fitting regression models are essential components of analytical reasoning and research skills, contributing to the overall objective of research and analytical reasoning.

CO5: Weightage: 3 (Strongly Related)

Justification: Diagnosing regression models involves critical analysis and problem-solving to identify issues such as Multicollinearity or heteroscedasticity, aligning closely with the objective of analytical reasoning and research skills.

CO6: Weightage: 3 (Strongly Related)

Justification: Validating regression models through hypothesis testing and confidence intervals demonstrates rigorous analytical reasoning and adherence to research ethics, supporting the objective of research, analytical reasoning, and ethical conduct.

PO 6: Communication, Collaboration, and Leadership

CO7: Weightage: 1 (Partially Related)

Justification: While understanding advanced regression techniques contributes to technical proficiency, it may not directly impact communication, collaboration, or leadership skills as much as other objectives. However, it still enhances problem-solving abilities and analytical skills.

PO 7: Digital Proficiency and Technological Skills

CO1: Weightage: 2 (Moderately Related)

Justification: While digital proficiency and technological skills do not directly involve regression modeling, understanding regression models may require the use of appropriate software and ICT tools for data analysis.

CO2: Weightage: 3 (Strongly Related)

Justification: Proficiency in using ICT and appropriate software is essential for implementing regression modeling approaches and conducting model selection procedures.

CO3: Weightage: 2 (Moderately Related)

Justification: Analyzing the connections between variables often involves data analysis using appropriate software, contributing to digital proficiency and technological skills.

CO4: Weightage: 3 (Strongly Related)

Justification: Digital proficiency and technological skills are necessary for estimating model parameters and fitting regression models using software tools.

CO5: Weightage: 2 (Moderately Related)

Justification: Proficiency in using ICT and data analysis software is crucial for performing diagnostics and assessing the quality of regression models.

CO6: Weightage: 3 (Strongly Related)

Justification: Utilizing hypothesis testing and confidence intervals for model validation requires proficiency in statistical software and digital tools.

CO7:. Weightage: 2 (Moderately Related)

Justification: While advanced regression techniques may not directly relate to digital proficiency, the implementation of these techniques often involves the use of specialized software and ICT tools.

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	: II
Course Type	: Major Mandatory Practical
Course Name	: Data Science Practical – III
Course Code	: DSC-553-MJM
No. of Credits	: 2
No. of Teaching Hours	: 60

Course Objectives:

1. To understand the principles and concepts underlying the general linear model and its application in statistical analysis.
2. To learn the application of Balance Incomplete Block Design (BIBD) with a focus on intra-block analysis.
3. To learn the techniques and interpretation involved in Analysis of 3^k factorial experiments, including identification and management of total and partial confounding.
4. To understand the concept of total confounding in 3^k factorial experiments and learn methods to address it effectively.
5. To develop proficiency in analyzing one-half and quarter fractional factorial experiments, including identifying significant factors and interactions.
6. To learn the principles and applications of Response Surface Methodology (RSM) using Central Composite Design (CCD) for optimizing response variables.

7. To understand the random effect model with one factor and estimation of variance to account for variability due to random factors.

Course Outcomes:

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

CO1. understand the theoretical foundation and practical applications of the general linear model in statistical analysis.

CO2. demonstrate proficiency in designing and analyzing experiments using the Balance Incomplete Block Design, including intra-block analysis techniques.

CO3. apply analysis of covariance (ANCOVA) in both one-way and two-way models to appropriately account for covariate effects in experimental designs.

CO4. interpret and analyze results from 2^k factorial experiments, including main effects, interactions, and optimization of experimental factors.

CO5. apply statistical techniques to analyze and interpret results from 3^k factorial experiments, considering total and partial confounding effects.

CO6. recognize and address total confounding in 3^k factorial experiments to ensure accurate interpretation of experimental results.

CO7. identify and address partial confounding in 3^k factorial experiments to mitigate potential biases in statistical analysis.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Analysis of general linear model
2.	Balance Incomplete Block Design (Intra block analysis)
3.	Analysis of Covariance in one way and two-way model
4.	Analysis of 2^k factorial experiments
5.	Analysis of 3^k factorial experiments
6.	Total Confounding in 3^k factorial experiment
7.	Partial Confounding in 3^k factorial experiment
8.	Analysis of one-half fractional factorial experiment
9.	Analysis of quarter fractional factorial experiment
10.	Response Surface Methodology I (Central Composite Design)
11.	Response Surface Methodology II (Box-Behnken Design)

12.	Random effect model with one factor, estimation of variance.
13.	Analysis of Split lot Design
14.	Analysis of Placket Berman design
15.	Taguchi methods: S/N ratio, orthogonal arrays, triangular tables, linear graphs, inner and outer arrays.

Programme Outcomes and Course Outcomes Mapping:

	Programme Outcomes(POs)									
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**
CO1	3	2	1	3	2	1	2	1	1	1
CO2	2	3	1	3	2	1	2	1	1	1
CO3	2	3	1	3	2	1	2	1	1	1
CO4	2	3	1	3	2	1	2	1	1	1
CO5	2	3	1	3	2	1	2	1	1	1
CO6	2	3	1	3	2	1	2	1	1	1
CO7	2	3	1	3	2	1	2	1	1	1

Justification:

PO1. Comprehensive Knowledge and Understanding:

CO1: Strongly Related (Weightage: 3)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

CO8: Moderately Related (Weightage: 2)

Justification: PO1 emphasizes comprehensive understanding, particularly in statistical analysis. CO1 directly aligns with this by focusing on the theoretical foundation and practical applications of the general linear model. CO2 to CO8 provide additional depth to this understanding by covering various experimental designs and statistical techniques, albeit not as directly as CO1.

PO2. Practical, Professional, and Procedural Knowledge:

CO1: Moderately Related (Weightage: 2)

CO2: Strongly Related (Weightage: 3)

CO3: Strongly Related (Weightage: 3)

CO4: Strongly Related (Weightage: 3)

CO5: Strongly Related (Weightage: 3)

CO6: Strongly Related (Weightage: 3)

CO7: Strongly Related (Weightage: 3)

CO8: Strongly Related (Weightage: 3)

Justification: PO2 revolves around practical knowledge and procedural skills, essential for statistical analysis. All the COs (CO1 to CO8) are strongly related as they directly contribute to developing proficiency in experimental design and statistical analysis techniques, which are crucial for practical applications in various fields.

PO3. Entrepreneurial Mindset, Innovation, and Business Understanding:

CO1: Partially Related (Weightage: 1)

CO2: Partially Related (Weightage: 1)

CO3: Partially Related (Weightage: 1)

CO4: Partially Related (Weightage: 1)

CO5: Partially Related (Weightage: 1)

CO6: Partially Related (Weightage: 1)

CO7: Partially Related (Weightage: 1)

CO8: Partially Related (Weightage: 1)

Justification: While statistical analysis skills are valuable in business contexts, the objectives (CO1 to CO8) do not directly address entrepreneurial mindset or business understanding. They mainly focus on technical skills relevant to statistical analysis.

PO4. Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: Strongly Related (Weightage: 3)

CO2: Strongly Related (Weightage: 3)

CO3: Strongly Related (Weightage: 3)

CO4: Strongly Related (Weightage: 3)

CO5: Strongly Related (Weightage: 3)

CO6: Strongly Related (Weightage: 3)

CO7: Strongly Related (Weightage: 3)

CO8: Strongly Related (Weightage: 3)

Justification: PO4 emphasizes specialized skills, critical thinking, and problem-solving abilities, all of which are directly addressed by the objectives (CO1 to CO8). These objectives focus on developing proficiency in experimental design, statistical analysis, and interpretation, contributing significantly to specialized skills and critical thinking.

PO5. Research, Analytical Reasoning, and Ethical Conduct:

CO1: Moderately Related (Weightage: 2)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

CO8: Moderately Related (Weightage: 2)

Justification*: While statistical analysis skills are relevant to research and analytical reasoning, the objectives (CO1 to CO8) do not directly address ethical conduct. However, they contribute to analytical reasoning and research skills, which are essential for conducting ethical research.

PO6. Communication, Collaboration, and Leadership:

All COs: Partially Related (Weightage: 1)

Justification: Statistical analysis skills can indirectly contribute to communication and collaboration in research contexts, but the objectives (CO1 to CO8) do not directly address communication, collaboration, or leadership skills.

PO7. Digital Proficiency and Technological Skills:

CO1: Moderately Related (Weightage: 2)

CO2: Moderately Related (Weightage: 2)

CO3: Moderately Related (Weightage: 2)

CO4: Moderately Related (Weightage: 2)

CO5: Moderately Related (Weightage: 2)

CO6: Moderately Related (Weightage: 2)

CO7: Moderately Related (Weightage: 2)

CO8: Moderately Related (Weightage: 2)

Justification: Statistical analysis often requires the use of digital tools and technology. While the objectives (CO1 to CO8) involve statistical analysis, they do not specifically focus on developing digital proficiency or technological skills.

PO8. Multicultural Competence, Inclusive Spirit, and Empathy:

All COs: Partially Related (Weightage: 1)

Justification: The objectives (CO1 to CO8) mainly focus on technical skills related to statistical analysis and do not directly address multicultural competence, inclusive spirit, or empathy.

PO9. Value Inculcation, Environmental Awareness, and Ethical Practices:

All COs: Partially Related (Weightage: 1)

Justification: While ethical considerations are important in research, the objectives (CO1 to CO8) do not directly address value inculcation, environmental awareness, or ethical practices.

PO10. Autonomy, Responsibility, and Accountability:

All COs: Partially Related (Weightage: 1)

Justification: While statistical analysis skills require autonomy, responsibility, and accountability, the objectives (CO1 to CO8) do not explicitly address these aspects.

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	: II
Course Type	: Major Mandatory Practical
Course Name	: Data Science Practical – IV
Course Code	: DSC-554-MJM
No. of Credits	: 2
No. of Teaching Hours	: 60

Course Objectives:

1. Students will learn to use numerical computing tools and programming languages, suchas MATLAB, Python, or R or Minitab, to implement and solve problems.
2. Students will learn how to apply linear regression models in practice, identify situation where linear regression is appropriate, build and fit linear regression models with software also interpret estimates and diagnostic statistics, produce exploratory graphs.
3. Students will learn to predict an ordinal dependent variable given one or more independent variables.
4. Students will learn to diagnose the presence of Multicollinearity in a model.
5. Students will learn Multicollinearity refers to a state wherein there exists inter-association or inter-relation between two or more independent variables.
6. Student should be able to understand when it is relevant to choose logistic regression.
7. Students should able to predict the value of the dependent variable for individuals for whom some information concerning the explanatory variables is available, or in order to estimate the effect of some explanatory variable on the dependent variable.

Course Outcomes:

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

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

CO2. Understand of model selection and regression modelling techniques should be demonstrated.

CO3. Understand **e**xcellent familiarity with both linear and nonlinear regression models.

CO4. Estimate the parameters and fit a model.

CO5. Investigate possible diagnostics in regression modeling and analysis concepts.

CO6. Predict categorical placement in or the probability of category membership on a dependent variable based on multiple independent variables.

CO7. Diagnose the presence of multicollinearity in a model.

Topics and Learning Points

Sr. No.	Title of Experiments
1.	Simple regression and regression diagnostic
2.	Multiple regression and regression diagnostic
3.	Lack of fit of the regression model
4.	Multiple regression (selection of variable)
5.	Detection of multicollinearity
6.	Dealing with multicollinearity by using Principle Component Regression
7.	Dealing with multicollinearity by using Ridge Regression
8.	Polynomial regression
9.	Non-linear regression
10.	Poisson regression
11.	Logistic regression
12.	Ordinary logistic regression
13.	Multinomial logistic regression.
14.	Case Study (Two Practical's).

Programme Outcomes and Course Outcomes Mapping:

	Programme Outcomes(POs)									
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**
CO1	3	3			3					
CO2	3	3			3					
CO3	3		2		3					
CO4	3		3		3					
CO5	3		2		3					
CO6	3			2	2					
CO7	2			2	2					

Justification:

PO 1: Comprehensive Knowledge and Understanding

CO1: Weightage: 3 (Strongly Related)

Justification: Proficiency in using statistical software aligns directly with the acquisition of practical skills and expertise necessary for professional tasks, as stated in PO 2.

CO2: Weightage: 3 (Strongly Related)

Justification: Understanding model selection and regression modeling techniques demonstrates proficiency in specialized skills, critical thinking, and problem-solving, as emphasized in PO 4.

CO3: Weightage: 3 (Strongly Related)

Justification: Demonstrating excellent familiarity with regression models contributes to comprehensive knowledge and understanding of statistical methodologies, which aligns with PO 1.

CO4: Weightage: 3 (Strongly Related)

Justification: Estimating model parameters and fitting models is a practical application of statistical techniques, demonstrating practical, professional, and procedural knowledge as outlined in PO 2.

CO5: Weightage: 2 (Moderately Related)

Justification: While investigating diagnostics in regression modeling may not directly involve digital proficiency and technological skills (PO 7), it contributes to research and analytical reasoning abilities, aligning with PO 5.

CO6: Weightage: 3 (Strongly Related)

Justification: Predictive modeling using multiple independent variables demonstrates proficiency in analytical reasoning and problem-solving, supporting the development of specialized skills as per PO 4.

CO7: Weightage: 2 (Moderately Related)

Justification: Diagnosing multicollinearity contributes to the critical evaluation of regression models, enhancing analytical abilities and aligning with the emphasis on specialized skills and critical thinking in PO 4.

PO 2: Practical, Professional, and Procedural Knowledge

CO1: Weightage: 3 (Strongly Related)

Justification: This course objective directly aligns with acquiring practical skills and expertise necessary for professional tasks, including the effective use of statistical software, which is essential for real-world applications.

CO2: Weightage: 3 (Strongly Related)

Justification: Model selection and regression modeling techniques are critical components of practical, professional knowledge required for analyzing data and making informed decisions in real-world scenarios.

PO 3: Entrepreneurial Mindset, Innovation, and Business Understanding

CO3: Weightage: 2 (Moderately Related)

Justification: While regression modeling is not directly related to entrepreneurial mindset and business understanding, understanding regression models can contribute to analyzing business data and making informed decisions.

CO4: Weightage: 3 (Strongly Related)

Justification: Estimating parameters and fitting models are essential skills for data analysis and decision-making, which are relevant to understanding business dynamics and fostering innovation.

CO5: Weightage: 2 (Moderately Related)

Justification: Diagnosing model diagnostics in regression analysis can enhance analytical reasoning skills, which are valuable for identifying business trends and opportunities.

PO 4: Specialized Skills, Critical Thinking, and Problem-Solving

CO6: Weightage: 2 (Moderately Related)

Justification: Predictive modeling skills are essential for problem-solving and critical thinking, which are important aspects of specialized skills required in various professional domains.

CO7: Weightage: 2 (Moderately Related)

Justification: Understanding multicollinearity and its impact on regression models requires critical thinking and problem-solving abilities, which are fundamental to specialized skills and analytical reasoning.

PO 5: Research, Analytical Reasoning, and Ethical Conduct

CO1: Weightage: 3 (Strongly Related)

Justification: Proficiency in using statistical software is crucial for conducting data analysis, which is essential for research and analytical reasoning.

CO2: Weightage: 3 (Strongly Related)

Justification: Understanding model selection and regression modeling techniques is directly related to research and analytical reasoning, as these methods are commonly used in data analysis for research purposes.

CO3: Weightage: 3 (Strongly Related)

Justification: Knowledge of regression models is fundamental for conducting statistical analysis in research, aligning with the emphasis on analytical reasoning in PO 5.

CO4: Weightage: 3 (Strongly Related)

Justification: Estimating model parameters and fitting regression models are essential components of data analysis in research, directly aligning with the objectives of analytical reasoning and research skills.

CO5: Weightage: 3 (Strongly Related)

Justification: Diagnosing and addressing issues in regression modeling are critical aspects of analytical reasoning and research, ensuring the validity and reliability of research findings.

CO6: Weightage: 2 (Moderately Related)

Justification: While predictive modeling techniques are valuable for research, they are not directly related to the formulation of research questions or adherence to research ethics.

CO7: Weightage: 2 (Moderately Related)

Justification: Understanding multicollinearity is important for ensuring the validity of regression models, but it is not directly tied to ethical conduct or observational skills emphasized in PO 5.

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	: II
Course Type	: Major Elective Theory
Course Name	: Bayesian Inference
Course Code	: DSC-561-MJE(A)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To learn about Bayesian inference setup, including prior and posterior distributions.
2. To explore loss functions and the principles of minimum expected posterior loss.
3. To perform point estimation, construct highest posterior density (HPD) confidence intervals, and make predictions of future observations using Bayesian methods.
4. To understand different classes of priors and their role in Bayesian inference.
5. To learn about Bayesian computing techniques, including the Expectation-Maximization (E-M) algorithm.
6. To discuss convergence diagnostics in Bayesian computation and apply them to assess the convergence of MCMC chains.
7. To understand Bayesian model selection methods such as Bayesian Information Criterion (BIC) and Bayes factors.

Course Outcomes:

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

CO 1. construct Bayesian prediction intervals and write appropriate conclusions.

CO 2. allows the incorporation of existing knowledge or beliefs through the prior distribution.

CO 3. performs well even with small sample sizes, especially when informative priors are available.

CO 4. use Bayes' theorem to combine the prior and likelihood, yielding the posterior distribution.

CO 5. provides probabilistic outputs, allowing for a natural expression of uncertainty in parameter estimates.

CO 6. apply Bayesian inference to solve real-world problems in various domains, such as finance, healthcare, and social sciences.

CO 7. understand and apply posterior predictive checks to assess the adequacy of Bayesian models in capturing the observed data patterns.

Topics and Learning Points

Unit 1 **(18L)**

Subjective and frequentist probability, Bayesian inference set up, prior and posterior distributions, loss functions, principles of minimum expected posterior loss, quadratic and other loss functions, advantages of being Bayesian, improper priors, Common problems of Bayesian Inference, point estimation, HPD confidence intervals, predictions of future observations, Bayesian testing.

Unit 2 **(12L)**

Bayesian analysis with subjective priors, classes priors, conjugate class of priors, Jeffrey's prior, probability matching prior, robustness and sensitivity.

Unit 3 **(12L)**

Bayesian model selection BIC, Bayes factors, limit of posterior distributions, consistency and asymptotic normality of posterior distributions.

Unit 4 **(18L)**

Bayesian computing, E-M Algorithm, MCMC, MH Algorithms, Gibb' sampling, convergence diagnostics. (Note: Minimum 10 hours of computational practice)

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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, Ramez Elmasri,(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
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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:

	Programme Outcomes(POs)									
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**
CO1	3	2	1	2	2	1	1	1		
CO2	3	2	1	2	2	1	1	1		
CO3	2	1	1	2	2	1	1	1		
CO4	3	2	1	2	2	1	1	1		
CO5	3	2	1	2	3	1	1	1		
CO6	3	3	2	3	3	2				
CO7	3	2	1	2	2	1				

Justification:

PO 1 Comprehensive Knowledge and Understanding

CO1 Weightage: 3 (Strongly Related)

Justification: Bayesian prediction intervals are an essential component of Bayesian analysis, contributing to a profound understanding of statistical inference within a multidisciplinary context.

CO2 Weightage: 3 (Strongly Related)

Justification: Understanding the role of prior distributions in Bayesian analysis enhances comprehension of foundational theories and methodologies in statistics and data analysis.

CO3 Weightage: 2 (Moderately Related)

Justification: Demonstrating the robustness of Bayesian methods with small sample sizes reinforces the importance of practical, professional, and procedural knowledge in statistical analysis.

CO 4 Weightage: 3 (Strongly Related)

Justification: Mastery of Bayes' theorem and its application in Bayesian inference is fundamental to developing a comprehensive understanding of statistical methodologies.

CO 5 Weightage: 3 (Strongly Related)

Justification: Understanding the probabilistic nature of Bayesian analysis contributes to analytical reasoning and critical thinking skills, essential for research and data analysis.

CO 6 Weightage: 3 (Strongly Related)

Justification: Application of Bayesian inference in real-world scenarios reinforces the interdisciplinary application of knowledge and skills, aligning with the multidisciplinary context of comprehensive knowledge and understanding.

CO 7 Weightage: 3 (Strongly Related)

Justification: Utilizing posterior predictive checks demonstrates competency in research, analytical reasoning, and ethical conduct by ensuring the validity and reliability of Bayesian models in data analysis and reporting findings.

PO 2 Practical, Professional, and Procedural Knowledge

CO 1 Weightage: 2 (Moderately Related)

Justification: Practical knowledge of constructing prediction intervals enhances skills necessary for professional tasks in statistical analysis and reporting.

CO 2 Weightage: 2 (Moderately Related)

Justification: Understanding the role of prior distributions contributes to procedural knowledge in Bayesian analysis, aligning with industry standards and ethical considerations in statistical modeling.

CO 3 Weightage: 1 (Partially Related)

Justification: While understanding the performance of Bayesian methods with small sample sizes is valuable for professional tasks, it may not directly correlate with practical or procedural knowledge.

CO 4 Weightage: 2 (Moderately Related)

Justification: Application of Bayes' theorem in Bayesian inference contributes to procedural knowledge necessary for statistical analysis and modeling in real-world scenarios.

CO 5 Weightage: 2 (Moderately Related)

Justification: Understanding probabilistic outputs in Bayesian analysis enhances practical knowledge of interpreting and communicating results effectively, aligning with professional standards in data analysis.

CO 6 Weightage: 3 (Strongly Related)

Justification: Application of Bayesian inference in real-world contexts develops practical skills necessary for professional tasks across diverse domains, demonstrating proficiency in procedural knowledge and industry standards.

CO 7 Weightage: 2 (Moderately Related)

Justification: Mastery of posterior predictive checks contributes to professional knowledge by ensuring the validity and reliability of Bayesian models in practical applications, aligning with industry standards and ethical considerations.

PO 3 Entrepreneurial Mindset, Innovation, and Business Understanding

CO 1 Weightage: 1 (Partially Related)

Justification: While Bayesian prediction intervals may not directly align with entrepreneurial mindset or business understanding, the ability to draw appropriate conclusions demonstrates analytical skills relevant to innovation and problem-solving.

CO 2 Weightage: 1 (Partially Related)

Justification: Understanding how prior distributions incorporate existing knowledge or beliefs may indirectly contribute to fostering an entrepreneurial mindset by encouraging critical thinking and creativity in decision-making processes.

CO 3 Weightage: 1 (Partially Related)

Justification: While the performance of Bayesian methods with small sample sizes may not directly relate to entrepreneurial mindset, the ability to adapt and make informed decisions under resource constraints aligns with entrepreneurial qualities.

CO 4 Weightage: 1 (Partially Related)

Justification: Understanding Bayes' theorem and its application in Bayesian analysis may indirectly contribute to business understanding by fostering logical reasoning and decision-making skills.

CO 5 Weightage: 1 (Partially Related)

Justification: While probabilistic outputs may not directly relate to business understanding, the ability to quantify and communicate uncertainty in decision-making processes aligns with entrepreneurial mindset and risk management strategies.

CO 6 Weightage: 2 (Moderately Related)

Justification: Application of Bayesian inference in diverse domains demonstrates innovation and adaptability, fostering an entrepreneurial mindset by addressing complex problems and identifying opportunities for improvement.

CO 7 Weightage: 1 (Partially Related)

Justification: Mastery of posterior predictive checks contributes to analytical skills and critical thinking, indirectly supporting an entrepreneurial mindset by ensuring the validity and reliability of data-driven decisions.

PO 4 Specialized Skills, Critical Thinking, and Problem-Solving

CO 1 Weightage: 2 (Moderately Related)

Justification: Bayesian prediction intervals require specialized skills in Bayesian analysis, which involve critical thinking and problem-solving to interpret and draw appropriate conclusions from the results.

CO2 Weightage: 2 (Moderately Related)

Justification: Incorporating prior knowledge or beliefs through the prior distribution requires critical thinking to assess the relevance and reliability of the prior information in the context of the problem being addressed.

CO3 Weightage: 2 (Moderately Related)

Justification: The ability of Bayesian analysis to perform well with small sample sizes, particularly with informative priors, highlights specialized skills in statistical modeling and critical thinking to effectively utilize available data for inference.

CO4 Weightage: 2 (Moderately Related)

Justification: Applying Bayes' theorem to combine prior knowledge with observed data to obtain the posterior distribution requires critical thinking and problem-solving skills to understand the underlying principles and make appropriate inferences.

CO5 Weightage: 2 (Moderately Related)

Justification: Understanding and interpreting probabilistic outputs in Bayesian analysis involve specialized skills in critical thinking to assess and communicate uncertainty, which is essential for effective problem-solving.

CO6 Weightage: 3 (Strongly Related)

Justification: Applying Bayesian inference to real-world problems requires specialized skills, critical thinking, and problem-solving abilities to adapt Bayesian methods to diverse domains and address complex challenges effectively.

CO7 Weightage: 2 (Moderately Related)

Justification: The ability to conduct posterior predictive checks involves critical thinking and problem-solving skills to evaluate the performance of Bayesian models and ensure their validity in capturing the underlying data patterns.

PO 5 Research, Analytical Reasoning, and Ethical Conduct

CO1 Weightage: 2 (Moderately Related)

Justification: Research and analytical reasoning skills are required to construct Bayesian prediction intervals, and ethical conduct is essential in accurately reporting conclusions drawn from the analysis.

CO2 Weightage: 2 (Moderately Related)

Justification: Research and analytical reasoning skills are necessary to evaluate existing knowledge or beliefs for incorporation into the prior distribution, ensuring that the Bayesian analysis reflects the relevant information available.

CO3 Weightage: 2 (Moderately Related)

Justification: Analytical reasoning skills are crucial in understanding the performance of Bayesian methods with small sample sizes, and ethical conduct is necessary to ensure the appropriate use of informative priors in such scenarios.

CO4 Weightage: 2 (Moderately Related)

Justification: Research and analytical reasoning skills are required to apply Bayes' theorem effectively in combining the prior and likelihood, while ethical conduct ensures the integrity of the posterior distribution obtained.

CO5 Weightage: 3 (Strongly Related)

Justification: Analytical reasoning skills are essential in understanding and interpreting probabilistic outputs in Bayesian analysis, which naturally express uncertainty in parameter estimates, contributing to ethical conduct in accurately conveying the level of uncertainty in research findings.

CO6 Weightage: 3 (Strongly Related)

Justification: Research and analytical reasoning skills are fundamental in applying Bayesian inference to real-world problems across different domains, ensuring that appropriate methodologies are utilized for data analysis while adhering to ethical conduct in research practices.

CO7 Weightage: 2 (Moderately Related)

Justification: Analytical reasoning skills are necessary to understand and apply posterior predictive checks effectively, ensuring that Bayesian models accurately capture the observed data patterns, which contributes to ethical conduct in research by validating the model's adequacy.

PO 6 Communication, Collaboration, and Leadership

CO1 Weightage: 1 (Partially Related)

Justification: While this objective focuses on analytical reasoning and reporting conclusions, effective communication skills are required to articulate findings clearly to various stakeholders.

CO2 Weightage: 1 (Partially Related)

Justification: Effective communication skills are necessary to understand and incorporate stakeholders' knowledge or beliefs into the Bayesian analysis, fostering collaboration and ensuring alignment with project objectives.

CO3 Weightage: 1 (Partially Related)

Justification: Collaboration skills are essential in discussing and determining the suitability of informative priors, especially in scenarios with limited data, to ensure the reliability of Bayesian analysis outcomes.

CO4 Weightage: 1 (Partially Related)

Justification: While this objective primarily involves analytical reasoning, effective communication skills are necessary to explain the Bayesian inference process to team members or stakeholders.

CO5 Weightage: 1 (Partially Related)

Justification: Communication skills are crucial in conveying the probabilistic nature of Bayesian outputs and the associated uncertainty to non-technical audiences, facilitating informed decision-making.

CO6 Weightage: 2 (Moderately Related)

Justification: Collaboration skills are required to work effectively with multidisciplinary teams in applying Bayesian inference to diverse real-world problems, ensuring effective communication and coordination to achieve common goals.

CO7 Weightage: 1 (Partially Related)

Justification: Effective communication skills are needed to explain the rationale behind posterior predictive checks and their implications for model adequacy to team members or stakeholders.

PO7: Digital Proficiency and Technological Skills

CO1: Weightage: 1 (Partially Related)

Justification: This objective involves utilizing statistical techniques and software tools, which may require digital proficiency and technological skills. However, it primarily focuses on statistical analysis rather than direct application of digital tools.

CO2: Weightage: 1 (Partially Related)

Justification: Understanding how to incorporate prior knowledge into Bayesian analysis may involve using software tools, but the emphasis is on statistical methodology rather than digital proficiency.

CO3: Weightage: 1 (Partially Related)

Justification: While digital tools may facilitate analysis with small sample sizes, this objective primarily concerns statistical methodology rather than digital proficiency.

CO4: Weightage: 1 (Partially Related)

Justification: This objective involves understanding Bayesian principles and mathematical concepts, which may involve using digital tools. However, the emphasis is on theoretical understanding rather than practical digital skills.

CO5: Weightage: 1 (Partially Related)

Justification: While digital tools may aid in generating probabilistic outputs, this objective primarily concerns statistical concepts and interpretation rather than direct digital proficiency.

PO8: Multicultural Competence, Inclusive Spirit, and Empathy

CO1: Weightage: 1 (Partially Related)

Justification: While this objective focuses on statistical analysis, it indirectly contributes to multicultural competence by fostering critical thinking and analytical skills, which are essential for understanding diverse perspectives.

CO2: Weightage: 1 (Partially Related)

Justification: Understanding how to incorporate prior knowledge into Bayesian analysis indirectly supports inclusive spirit by recognizing and respecting diverse viewpoints and beliefs in the decision-making process.

CO3: Weightage: 1 (Partially Related)

Justification: While statistical analysis techniques are the focus here, the ability to handle small sample sizes and incorporate informative priors demonstrates adaptability, a quality valuable in multicultural settings.

CO4: Weightage: 1 (Partially Related)

Justification: Understanding Bayesian principles involves considering prior beliefs and updating them based on new evidence, which aligns with the principles of inclusivity and empathy towards diverse perspectives.

CO5: Weightage: 1 (Partially Related)

Justification: The ability to express uncertainty in parameter estimates acknowledges the complexity of real-world scenarios and fosters empathy by recognizing and respecting uncertainty in decision-making.

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	: II
Course Type	: Major Elective Theory
Course Name	: Computational Statistics
Course Code	: DSC-561-MJE(B)
No. of Credits	: 4
No. of Teaching Hours	: 60

Course Objectives:

1. To understand the theory behind the inverse transformation method (ITM) for generating random variates.
2. To utilize iterative methods including Jacobi and Gauss-Seidel methods for solving systems of linear equations..
3. To explore variance stabilizing transformations and their application in statistical analysis.
4. To analyze the convergence properties and limitations of various numerical methods for nonlinear equations and optimization problems.
5. To perform numerical differentiation using forward and backward difference methods and analyze the associated errors.
6. To implement Monte Carlo methods, including Monte Carlo integration, to compute expected values and probabilities..
7. To analyze the strengths and limitations of Monte Carlo methods in various computational settings.

Course Outcomes:

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

CO 1. employ computational techniques to provide numerical solutions to statistical questions that are challenging or unsolvable analytically.

CO 2. apply numerical techniques for transformations, for function approximation.

CO 3. understand and implement the Monte Carlo Studies in Statistics and random number generators.

CO 4. construct interpolating polynomials using Lagrange interpolation and Newton's divided difference method.

CO 5. calculating the estimator by using Jack-knife and Bootstrap, and comparing the average of these estimates to the original estimator, yielding a quantification of bias.

CO 6. apply numerical methods to solve problems encountered in data science, machine learning, and statistical analysis.

CO 7. use numerical optimization in the context of machine learning algorithms.

Topics and Learning Points

Unit 1 **(15 L)**

Theory of inverse transformation method (ITM) for random variate generation- definition of quantile function, its properties. Quantile function as a random variable and its distribution function. ITM based algorithms to generate random variates from standard discrete and continuous distributions. Generation of random variates using the relationships between distributions, composition and convolution methods. Algorithms for random variate generation from mixture distributions, Chi-square, t and F-distributions. Random variate generation from bivariate and conditional distributions. Theory of random number generation, testing a random number generator- run test, Kolmogorov-Smirnov test, sign test, rank test. Selection of a random number generator.

Unit 2 **(15 L)**

Solutions to Non-linear equations: Bisection method, Newton Raphson, Steepest descent, Quadrature interpolation, Jacobi and Gauss Seidel Methods. Simple Optimization method. Direct search, grid search, Hooke & Jeeves method Interpolatory search, Gradient search.

Unit 3 **(15 L)**

Numerical Differentiation: Forward and backward Difference, Error analysis: True solution, Approximate numerical solution, Causes of error. Numerical Integration: Trapezoidal rule, Simpson’s Rule. Jack-knife and Bootstrap sampling. Bias and standard errors, Bootstrapping for estimation of sampling distribution. Confidence intervals, variance stabilizing transformation.

Unit 4 **(15 L)**

Methods to compute integrals- quadrature formula, double integration, Gaussian integration, Monte Carlo Methods: Monte Carlo integration and its application to compute expected

values and probabilities, Verification of WLLN, CLT and other approximations through simulation.

References:

1. Atkinson K. E. (1989): An Introduction to Numerical Analysis. (Wiley)
2. Devroye L. (1986) : Non- Uniform Random Variate Generation. (Springer- Verlag New York)
3. Ephron B. and Tibshirani. R. J. (1994): An Introduction to the Bootstrap. (Chapman and Hall) 4. Morgan B. J. T.(1984) : Elements of Simulation. (Chapman and Hall)
4. Robert C. P. and Casella G. (1999): Monte Carlo Statistical Methods. (Springer Verlag New York, Inc.)
5. Ross. S. M. (2006): Simulation. (Academic Press Inc)
6. Rubinstein, R. Y. (1998) Modern Simulation and Modelling. (Wiley Series in Probability and Statistics)
7. William J., Kennedy, James E. Gentle. (1980): Statistical Computing. (Marcel Dekker)

Programme Outcomes and Course Outcomes Mapping:

	Programme Outcomes(POs)									
Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO 10**
CO1	2	3	1	3	2	1	2	1	1	1
CO2	2	2	1	2	1	1	2	1	1	1
CO3	3	2	1	3	2	1	3	1	1	1
CO4	2	1	1	2	1	1	1	1	1	1
CO5	3	3	1	3	3	1	2	1	1	1
CO6	3	3	1	3	2	1	3	1	1	1
CO7	2	3	1	3	2	1	3	1	1	1

Justification:

PO1 Comprehensive Knowledge and Understanding:

CO1: Weightage: 2 (Moderately Related)

Justification: Computational techniques provide a practical approach to understanding complex statistical concepts, enhancing the depth of knowledge and understanding in the field.

CO2: Weightage: 2 (Moderately Related)

Justification: Understanding numerical techniques aids in grasping foundational theories and methodologies by providing practical applications and approximations.

CO3: Weightage: 3 (Strongly Related)

Justification: Monte Carlo studies and random number generation are fundamental aspects of statistical analysis, directly contributing to a profound understanding of statistical theories and methodologies.

CO4: Weightage: 2 (Moderately Related)

Justification: While polynomial interpolation techniques are specific mathematical methods, they enhance problem-solving skills and reinforce understanding of mathematical concepts underlying statistical methodologies.

CO5: Weightage: 3 (Strongly Related)

Justification: Understanding bias estimation techniques through Jack-knife and Bootstrap methods directly relates to observational and inquiry skills, essential for research and analytical reasoning.

CO6: Weightage: 3 (Strongly Related)

Justification: Applying numerical methods in data science and statistical analysis reinforces practical knowledge and enhances problem-solving abilities, aligning with the goal of comprehensive understanding.

CO7: Weightage: 2 (Moderately Related)

Justification: While numerical optimization focuses on specific techniques, its application in machine learning broadens the understanding of statistical methods in real-world scenarios, contributing to comprehensive knowledge and understanding.

PO2 Practical, Professional, and Procedural Knowledge:

CO1: Weightage: 3 (Strongly Related)

Justification: Computational techniques are practical skills necessary for addressing statistical questions in real-world scenarios, aligning with the acquisition of practical and procedural knowledge.

CO2: Weightage: 2 (Moderately Related)

Justification: Numerical techniques enhance practical knowledge by providing methods for approximating functions and transforming data, contributing to the acquisition of procedural knowledge in statistical analysis.

CO3: Weightage: 2 (Moderately Related)

Justification: Monte Carlo studies and random number generators are practical tools used in statistical analysis, contributing to the development of procedural knowledge and professional skills in the field.

CO4: Weightage: 1 (Partially Related)

Justification: While polynomial interpolation techniques are valuable mathematical skills, they are less directly applicable to practical statistical tasks, reducing their relevance to the acquisition of procedural knowledge.

CO5: Weightage: 3 (Strongly Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are essential practical skills for assessing bias in statistical analysis, aligning closely with the acquisition of procedural knowledge and professional competency.

CO6: Weightage: 3 (Strongly Related)

Justification: Application of numerical methods in various domains, including data science and machine learning, demonstrates practical competence and procedural knowledge relevant to professional tasks in statistical analysis.

CO7: Weightage: 3 (Strongly Related)

Justification: Utilizing numerical optimization techniques in machine learning applications enhances practical knowledge and procedural skills, contributing to professional competence in statistical analysis.

PO3 Entrepreneurial Mindset, Innovation, and Business Understanding:

CO1: Weightage: 1 (Partially Related)

Justification: While computational techniques may foster innovation and problem-solving, they do not directly address entrepreneurial mindset or business understanding.

CO2: Weightage: 1 (Partially Related)

Justification: Numerical techniques for function approximation are essential for data analysis but do not directly contribute to entrepreneurial mindset or business understanding.

CO3: Weightage: 1 (Partially Related)

Justification: While Monte Carlo studies involve computational methods, they are not directly related to entrepreneurial mindset or business understanding.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that may not directly contribute to entrepreneurial mindset or business understanding.

CO5: Weightage: 1 (Partially Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are important for statistical analysis but do not directly relate to entrepreneurial mindset or business understanding.

CO6: Weightage: 1 (Partially Related)

Justification: While numerical methods are crucial for problem-solving in various domains, they do not directly enhance entrepreneurial mindset or business understanding.

CO7: Weightage: 1 (Partially Related)

Justification: Numerical optimization techniques are important for machine learning but do not directly contribute to entrepreneurial mindset or business understanding.

PO4 Specialized Skills, Critical Thinking, and Problem-Solving:

CO1: Weightage: 3 (Strongly Related)

Justification: Computational techniques are fundamental for problem-solving in statistical analysis, requiring specialized skills and critical thinking to implement numerical solutions effectively.

CO2: Weightage: 2 (Moderately Related)

Justification: While numerical techniques involve critical thinking and problem-solving skills, their direct application in statistical analysis may be more specialized, making them moderately related to specialized skills and problem-solving.

CO3: Weightage: 3 (Strongly Related)

Justification: Monte Carlo studies require specialized skills and critical thinking to implement effectively, contributing to problem-solving in statistical analysis and simulation.

CO4: Weightage: 2 (Moderately Related)

Justification: Polynomial interpolation techniques involve critical thinking and problem-solving skills but may not be directly related to specialized skills in statistical analysis, making them moderately related to this outcome.

CO5: Weightage: 3 (Strongly Related)

Justification: Estimation techniques such as Jack-knife and Bootstrap require specialized skills and critical thinking to assess bias and improve the accuracy of estimators, directly contributing to problem-solving in statistical analysis.

CO6: Weightage: 3 (Strongly Related)

Justification: Application of numerical methods in data science and statistical analysis demands specialized skills and critical thinking to solve complex problems effectively.

CO7: Weightage: 3 (Strongly Related)

Justification: Numerical optimization techniques are crucial for optimizing machine learning algorithms, requiring specialized skills and critical thinking to address optimization challenges effectively.

PO5 Research, Analytical Reasoning, and Ethical Conduct:

CO1: Weightage: 2 (Moderately Related)

Justification: Computational techniques are often utilized in research and analytical reasoning to solve statistical questions, albeit the direct focus is on numerical solutions rather than the broader aspects of research and analytical reasoning.

CO2: Weightage: 1 (Partially Related)

Justification: While numerical techniques are important for data analysis, they are not directly tied to the formulation of research questions or the analytical reasoning process.

CO3: Weightage: 2 (Moderately Related)

Justification: Monte Carlo studies involve utilizing computational methods to analyze statistical problems, contributing to the research and analytical reasoning process, although they are not the sole focus.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that may not directly align with the research process or analytical reasoning in statistical analysis.

CO5: Weightage: 3 (Strongly Related)

Justification: Estimation techniques such as Jack-knife and Bootstrap are integral parts of research and analytical reasoning in statistical analysis, providing insights into bias and improving the accuracy of estimators.

CO6: Weightage: 2 (Moderately Related)

Justification: Numerical methods play a role in solving problems encountered in data science and statistical analysis, contributing indirectly to the research and analytical reasoning process.

CO7: Weightage: 2 (Moderately Related)

Justification: Numerical optimization techniques are relevant for optimizing machine learning algorithms, which can be part of the research and analytical reasoning process in statistical analysis, although they may not be the primary focus.

PO6 Communication, Collaboration, and Leadership:

CO1: Weightage: 1 (Partially Related)

Justification: While computational techniques may enhance communication and collaboration through the analysis of statistical data, they are not directly related to communication, collaboration, or leadership skills themselves.

CO2: Weightage: 1 (Partially Related)

Justification: Numerical techniques for transformations and function approximation are important for data analysis but do not directly contribute to communication, collaboration, or leadership skills.

CO3: Weightage: 1 (Partially Related)

Justification: While Monte Carlo studies involve computational methods, they are not directly tied to communication, collaboration, or leadership skills.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that may not directly contribute to communication, collaboration, or leadership skills.

CO5: Weightage: 1 (Partially Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are essential for statistical analysis but do not directly relate to communication, collaboration, or leadership skills.

CO6: Weightage: 1 (Partially Related)

Justification: While numerical methods are crucial for solving problems in data science and statistical analysis, they do not directly enhance communication, collaboration, or leadership skills.

CO7: Weightage: 1 (Partially Related)

Justification: Numerical optimization techniques are important for machine learning but do not directly contribute to communication, collaboration, or leadership skills.

PO7 Digital Proficiency and Technological Skills:

CO1: Weightage: 2 (Moderately Related)

Justification: Computational techniques involve the use of software and technology to analyze statistical data, demonstrating proficiency in utilizing ICT and software for data analysis.

CO2: Weightage: 2 (Moderately Related)

Justification: Numerical techniques often require the use of software tools for implementation, showcasing proficiency in utilizing technology for mathematical computations.

CO3: Weightage: 3 (Strongly Related)

Justification: Monte Carlo studies and random number generators are essential components of digital proficiency in statistical analysis, requiring knowledge and skills in using specialized software tools and algorithms.

CO4: Weightage: 1 (Partially Related)

Justification: While polynomial interpolation techniques may involve some computational implementation, they are not directly focused on digital proficiency or technological skills.

CO5: Weightage: 2 (Moderately Related)

Justification: Utilizing Jack-knife and Bootstrap methods often involves computational implementations, contributing to digital proficiency in statistical analysis.

CO6: Weightage: 3 (Strongly Related)

Justification: Applying numerical methods in data science and statistical analysis requires proficiency in utilizing software tools and technology for problem-solving.

CO7: Weightage: 3 (Strongly Related)

Justification: Numerical optimization techniques are crucial in machine learning, requiring proficiency in using software tools and algorithms for optimization tasks, thereby demonstrating digital proficiency and technological skills.

PO8 Multicultural Competence, Inclusive Spirit, and Empathy:

CO1: Weightage: 1 (Partially Related)

Justification: Computational techniques do not directly contribute to multicultural competence, inclusive spirit, or empathy.

CO2: Weightage: 1 (Partially Related)

Justification: While numerical techniques are important for data analysis, they do not directly address multicultural competence, inclusive spirit, or empathy.

CO3: Weightage: 1 (Partially Related)

Justification: Monte Carlo studies and random number generators are statistical tools that do not directly relate to multicultural competence, inclusive spirit, or empathy.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that do not directly contribute to multicultural competence, inclusive spirit, or empathy.

CO5: Weightage: 1 (Partially Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are important for statistical analysis but do not directly enhance multicultural competence, inclusive spirit, or empathy.

CO6: Weightage: 1 (Partially Related)

Justification: Numerical methods are crucial for problem-solving but do not directly address multicultural competence, inclusive spirit, or empathy.

CO7: Weightage: 1 (Partially Related)

Justification: Numerical optimization techniques are important for machine learning but do not directly contribute to multicultural competence, inclusive spirit, or empathy.

PO9 Value Inculcation, Environmental Awareness, and Ethical Practices:

CO1: Weightage: 1 (Partially Related)

Justification: While computational techniques are valuable in statistical analysis, they do not directly address value inculcation, environmental awareness, or ethical practices.

CO2: Weightage: 1 (Partially Related)

Justification: Numerical techniques, while important for various applications, do not directly contribute to value inculcation, environmental awareness, or ethical practices.

CO3: Weightage: 1 (Partially Related)

Justification: Monte Carlo studies and random number generators are statistical tools that do not directly relate to value inculcation, environmental awareness, or ethical practices.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that do not directly contribute to value inculcation, environmental awareness, or ethical practices.

CO5: Weightage: 1 (Partially Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are important for statistical analysis but do not directly enhance value inculcation, environmental awareness, or ethical practices.

CO6: Weightage: 1 (Partially Related)

Justification: While numerical methods are essential in problem-solving, they do not directly address value inculcation, environmental awareness, or ethical practices.

CO7: Weightage: 1 (Partially Related)

Justification: Numerical optimization techniques are crucial in machine learning but do not directly contribute to value inculcation, environmental awareness, or ethical practices.

PO10 Autonomy, Responsibility, and Accountability:

CO1: Weightage: 1 (Partially Related)

Justification: While computational techniques are important for problem-solving, they do not directly address autonomy, responsibility, or accountability.

CO2: Weightage: 1 (Partially Related)

Justification: Numerical techniques are valuable in various applications but do not directly contribute to autonomy, responsibility, or accountability.

CO3: Weightage: 1 (Partially Related)

Justification: Monte Carlo studies and random number generators are statistical tools that do not directly relate to autonomy, responsibility, or accountability.

CO4: Weightage: 1 (Partially Related)

Justification: Polynomial interpolation techniques are mathematical methods that do not directly enhance autonomy, responsibility, or accountability.

CO5: Weightage: 1 (Partially Related)

Justification: Estimation techniques like Jack-knife and Bootstrap are important for statistical analysis but do not directly address autonomy, responsibility, or accountability.

CO6: Weightage: 1 (Partially Related)

Justification: While numerical methods are crucial for problem-solving, they do not directly contribute to autonomy, responsibility, or accountability.

CO7: Weightage: 1 (Partially Related)

Justification: Numerical optimization techniques are essential in machine learning but do not directly enhance autonomy, responsibility, or accountability.