Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Course Structure for S. Y. B. Sc. STATISTICS

Semester	Paper Code	Title of Paper	No. of Credits
III	STAT2301	Statistical Techniques- I	3
	STAT2302	Continuous Probability Distributions-I	3
	STAT2303	Practical-I	2
IV	STAT2401	Statistical Techniques- II	3
	STAT2402	Continuous Probability Distributions-II	3
	STAT2403	Practical-II	2

Program Outcomes

PO1	**Disciplinary Knowledge:** Demonstrate comprehensive knowledge of the disciplines that form a part of a graduate programme. Execute strong theoretical and practical understanding generated from the specific graduate programme in the area of work.
PO2	**Critical Thinking and Problem solving:** Exhibit the skills of analysis, inference, interpretation and problem-solving by observing the situation closely and design the solutions.
PO3	**Social competence:** Display the understanding, behavioural skills needed for successful social adaptation , work in groups, exhibit thoughts and ideas effectively in writing and orally

PO4	**Research-related skills and Scientific temper :** Develop the working knowledge and applications of instrumentation and laboratory techniques. Able to apply skills to design and conduct independent experiments, interpret, establish hypothesis and inquisitiveness towards research.
PO5	**Trans-disciplinary knowledge:** Integrate different disciplines to uplift the domains of cognitive abilities and transcend beyond discipline-specific approaches to address a common problem
PO6	**Personal and professional competence:** Performing dependently and also collaboratively as a part of a team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	**Effective Citizenship and Ethics:** Demonstrate empathetic social concern and equity centred national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	**Environment and Sustainability:** Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	**Self-directed and Life-long learning:** Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes.

SYLLABUS(CBCS) FOR S. Y. B. Sc. STATISTICS (w.e. from June, 2020)
(2019 Pattern)

Academic Year 2020-2021

Class : **S.Y. B. Sc. (Semester- IV)**
Paper Code: **STAT2401**
Paper : **I** Title of Paper : Statistical Techniques- II
Credit : 3credits No. of lectures: 48

A) Course Objectives:

The main objective of this course is to acquaint students with the concepts of Statistical Process Control, M/M/1: FIFO Queuing model.

By the end of course students are expected to be able to

1. Identify real life situations where multiple regression can be used.
2. Use of R Software in statistical computing.
3. Understand meaning and use of SPC, construction and working of control charts for variables and attributes.

B) Course Outcomes:

Students should be able to:

CO1. Apply multiple regression in real life situations.
CO2. Use R Software in statistical computing.
CO3. Learn Meaning and purpose of SPC.
CO4. Construct Control charts for Attributes.
CO5. Construct Control charts for variables.
CO6. Revise control limits whenever necessary.
CO7. Apply M/M/1:FIFO Queuing model.

TOPICS/CONTENTS:

UNIT1: Multiple Linear Regression Model (trivariate case) (18L)

1.1 Definition of multiple correlation coefficient $R_{i.jk}$ $i,j,k = 1,2,3.$

1.2 Properties of multiple correlation coefficient)

1.2.1) $0 \leq R_{i.jk} \leq 1$ $i,j,k = 1,2,3$

1.2.2) $R_{i.jk} \geq Max\{|r_{ij}|, |r_{ik}|, |r_{ij.k}|, |r_{ik.j}|\}$ for $i \neq j \neq k. i,j,k = 1,2,3$

1.3 Interpretation of

1.3.1) coefficient of multiple determination $R^2_{i.jk}$

1.3.2) $R^2_{1.23} = 1$

1.3.3) $R^2_{1.23} = 0$

1.4 Definition of partial correlation coefficient

1.5 Notion of multiple linear regression Yule's notation $R_{1.23}$

1.6 Fitting of regression plane of Y on X_1 and X_2, $Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$, by the method of least squares; obtaining normal equations, solutions of normal equations.

1.7 Residuals : Definition, order, derivation of variance, properties.

1.8 Properties of partial regression coefficient

1.8.1) $-1 \leq r_{ij.k} \leq 1$ for i,j,k=1,2,3: $i \neq j \neq k$

1.8.2) $b_{12.3} \times b_{21.3} = r_{12.3}^2$

UNIT 2: Statistical Process Control **(18 L)**

2.1 Introduction: Meaning and purpose of Statistical Process Control, quality of a product, chance and assignable causes of variation.

2.2 Shewhart's Control chart: Statistical basis of control chart, 3 sigma limits, justification of 3 sigma limits and criteria for detecting lack of control.

2.3 Control charts for variables: Construction of control chart for mean and range when (i) standards are given and (ii) standards are not given. Revised control limits, interpretation from the charts and determination of process mean and standard deviation from the charts.

2.4 Control charts for attributes : Defects, defectives, fraction defective

2.4.1) p - chart

(a) Construction and working of p-chart when subgroup sizes are same and value of the process fraction defective p is specified: control limits, drawing of control chart, plotting of sample fraction defectives. Determination of state of control of the process.

(b) p-chart when subgroups sizes are different and value of the process fraction defective p is not specified with separate control limits, drawing of control chart, plotting sample fraction defectives, determination of state of control of the process. Interpretation of high and low spots.

2.4.2) c- chart

(a) Construction of c-chart **when standard is given**; control limits justification of 3 sigma limits, drawing of control chart, plotting number of defects per unit.

(b) Construction of c chart **when standard is not given**; control limits, explanation for the use of 3 sigma limits, drawing of control chart. Plotting number of defects per unit. Determination of state of control, interpretation of high and low spots in above cases.

UNIT 3: Queuing Model: **(6 L)**

3.1 Introduction to queuing theory

3.2 Terms used in queuing model.

Queue, Calling Population, Service stations (Or servers), Arrival rate, departure rate, Service discipline.

3.3 M/M/1: FIFO queuing model. An application of exponential distribution, Poisson distribution and geometric distribution: Inter arrival rate (λ), service rate (μ), traffic intensity (ρ), queue discipline, probability distribution of number of customers in queue, average queue length, average waiting time in: i) queue, ii) system.

UNIT 4: Statistical Computing Using R Software **(6 L)**

4.1 Computation of probability, cumulative probability, quantiles and drawing random samples using p, q, d, r functions (exponential, normal, Gamma, χ^2, t, F distributions)

4.2 Drawing a sample from population using SRSWR, SRSWOR.

4.3 Tests: Z test, t test, F test, proportions test, chi-square test for independents of attributes and goodness of fit.

References:

1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), Fundamentals of Statistics, Vol. 2, World Press, Kolkata.
2. Gupta, S. C. and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, (Eleventh Edition), Sultan Chand and Sons, 23, Daryaganj, New Delhi , 110002 .
3. Gupta, S. C. and Kapoor V. K. (2007), Fundamentals of Applied Statistics (Fourth Edition), Sultan Chand and Sons, New Delhi.
4. Gupta, S. P. (2002), Statistical Methods (Thirty First Edition), Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
5. Hogg, R. V. and Craig, A. T. , Mckean J. W. (2012), Introduction to Mathematical Statistics (Tenth Impression), Pearson Prentice Hall.
6. Montgomery, D. C. (1983). Statistical Quality Control, John Wiley and Sons, Inc., New York.
7. Duncan A.J. (1974). Quality Control and Industrial Statistics,fourth edition D.B. Taraporewala Sons and Co. Pvt. Ltd., Mumbai.
8. Grant, E. L. and Leavenworth (1980). Statistical Quality Control, fifth edition, Mc-Graw Hill, New Delhi.
9. Taha, H.A. (2007). Operation research: An Introduction, eighth edition, Prentice Hall of India, New Delhi.
10. Kapoor, V. K.(2006). Operations Research, S. Chand and Sons. New Delhi.
11. Vishwas R. Pawgi.Statistical Computing Using R Software.

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

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

PO1: Disciplinary Knowledge

CO1: Apply multiple regression in real-life situations.

Weight: 3 (Strongly Related)

Justification: Multiple regression is a statistical technique that falls within the domain of disciplinary knowledge in statistics. Applying it in real-life situations directly enhances the understanding and application of disciplinary knowledge.

CO2: Use R Software in statistical computing.

Weight: 2 (Moderately Related)

Justification: While the use of R Software is essential in statistical computing, it may not be directly tied to disciplinary knowledge but is a valuable skill supporting the application of statistical methods.

CO3: Learn Meaning and purpose of SPC.

Weight: 3 (Strongly Related)

Justification: Statistical Process Control (SPC) is integral to understanding and maintaining quality in various disciplines. It directly contributes to disciplinary knowledge related to quality control.

CO4: Construct Control charts for Attributes.

Weight: 3 (Strongly Related)

Justification: Constructing control charts for attributes is a practical application of SPC, aligning with the principles of disciplinary knowledge in statistical quality control.

CO5: Construct Control charts for variables.

Weight: 3 (Strongly Related)

Justification: Similar to CO4, constructing control charts for variables is a specific application of SPC in the context of variable data, enhancing disciplinary knowledge.

CO6: Revise control limits whenever necessary.

Weight: 2 (Moderately Related)

Justification: While understanding when and how to revise control limits is important, it is more of a practical skill than a direct enhancement of disciplinary knowledge.

CO7: Apply M/M/1:FIFO Queuing model.

Weight: 2 (Moderately Related)

Justification: Queuing models are part of operations research, and while relevant, they may not be directly tied to disciplinary knowledge in statistics.

PO2: Critical Thinking and Problem Solving

Weight: 3 (Strongly Related)

All COs contribute to critical thinking and problem-solving skills, as they involve applying statistical methods to solve real-world problems.

PO3: Social Competence Exhibit thoughts and ideas effectively in writing and orally

CO1, CO2, CO3, CO7

Weight: 2 (Moderately Related)

Justification: These outcomes may involve communicating statistical findings, but social competence may require additional skills beyond statistical knowledge.

PO4: Research-Related Skills

CO1, CO2, CO3, CO4, CO5, CO6, CO7

Weight: 3 (Strongly Related)

Justification: These outcomes involve skills essential for research in statistical methods, data

analysis, and quality control.

PO5: Personal and Professional Competence

All COs

Weight: 3 (Strongly Related)

Justification: Proficiency in statistical methods, R Software, SPC, and queuing models directly contributes to personal and professional competence.

PO6: Effective Citizenship and Ethics

CO3, CO6

Weight: 2 (Moderately Related)

Justification: Understanding the meaning and purpose of SPC and revising control limits ethically contribute to effective citizenship and ethical behavior.

PO8: Self-directed and Life-long Learning

CO2, CO6, CO7

Weight: 3 (Strongly Related)

Justification: Using R Software, revising control limits, and engaging in trans-disciplinary research contribute to self-directed and life-long learning.

PO9: Trans-disciplinary Research Competence

CO7

Weight: 3 (Strongly Related)

Justification: Trans-disciplinary research competence is directly addressed in the application of statistical methods across different disciplines.

SYLLABUS(CBCS) FOR S. Y. B. Sc. STATISTICS (w. e. from June, 2020)
(2019 Pattern)
Academic Year 2020-2021

Class : **S.Y. B. Sc. (Semester- IV)**
Paper Code: STAT 2402
Paper : **II** Title of Paper : Continuous Probability Distribution II
Credit : 3credits No. of lectures: 48

A) Course Objectives:

1.The main objective of this course is to acquaint students with the Exact Sampling Distributions and their applications.
2. Find various measures of r.v. and probabilities using its probability distributions
2. Know the relations among the different distributions
3. To study derived distributions and their applications

B) Course Outcome:

Students should be able to:

CO1. Understand Chi-Square distribution, Student's t- distribution, Snedecor's F distribution.
CO2. Compute means, mode, variance, moments, cumulants for above Distributions.
CO3. Apply Exact Sampling Distributions.
CO4. Know the relations among the different distributions.
CO5. Understand fundamental statistical concepts, including null hypothesis, alternative hypothesis, significance level, p-value, and Type I and Type II errors.
CO6. Learn to apply testing of hypothesis in real life situations.
CO7. Demonstrate the ability to use statistical reasoning in decision-making processes.

TOPICS/CONTENTS:

UNIT 1: Chi-square (χ^2_n) Distribution: (08 L)

1.1 Definition of χ^2 r. v. as sum of squares of i.i.d. standard normal variables, derivation of p.d.f. of χ^2 with n degrees of freedom (d.f.) using M.G.F., nature of p.d.f. curve, computations of probabilities using tables of χ^2 distribution. mean, variance, M.G.F., C.G.F., central moments, β_1, β_2, γ_1, γ_2, mode, additive property.

1.2 Normal approximation: $\frac{\chi^2_n - n}{\sqrt{2n}}$ with proof.

1.3 Distribution of $\frac{X}{X+Y}$ and $\frac{X}{Y}$, where X and Y are two independent chi-square random variables.

UNIT 2: Student's t-distribution: (05 L)

2.1 Definition of T r. v. with n d.f. in the form $\frac{U}{\sqrt{\chi_n^2/n}}$ where U $\rightarrow$ N(0, 1) and χ_n^2 is a χ^2 r. v. with n d.f. and U and χ_n^2 are independent r.v.s.

2.2 Derivation of p. d. f., nature of probability curve, mean, variance, moments, mode, use of tables of t-distribution for calculation of probabilities, statement of normal approximation.

UNIT 3: Snedecore's F-distribution: (05 L)

3.1 Definition of F r.v. with n_1 and n_2 d.f. as $F_{n_1,n_2} = \frac{\chi_{n_1}^2/n_1}{\chi_{n_2}^2/n_2}$ where $\chi_{n_1}^2$ and $\chi_{n_2}^2$ are independent chi-square r.v.s. with n_1 and n_2 d.f. respectively.

3.2 Derivation of p.d.f., nature of probability curve, mean, variance, moments, mode.

3.3 Distribution of $1/F_{n_1,n_2}$, use of tables of F-distribution for calculation of probabilities.

3.4 Interrelations among, χ^2, t and F variates.

UNIT 4: Basic concept of Testing of Hypothesis and Sampling Distributions: (10 L)

4.1 Random sample from a distribution as i.i.d. r.v.s. $X_1, X_2,\ldots, X_n$. Statistics and parameters, statistical inference: problem of estimation and testing of hypothesis. Estimator and estimate. Statisical hypothesis, null and alternative hypothesis, one sided and two sided alternative hypothesis, critical region, type I error, type II error, level of significance, p-value. Confidence interval.

4.2 Notion of a statistic as function of $X_1, X_2,\ldots, X_n$ with illustrations.

4.3 Sampling distribution of a statistic. Distribution of sample mean $\bar{x}$ from normal, exponential and gamma distribution, Notion of standard error of a statistic.

4.4 Distribution of $\frac{nS^2}{\sigma^2} = \frac{1}{\sigma^2}\sum_{i=1}^{n}\left(X_i - \overline{X}\right)_2$ for a sample from a normal distribution using orthogonal transformation. Independence $\bar{x}$ of and S^2.

UNIT 5: Test of Hypothesis: (20 L)

5.1 Large Sample Tests (Tests based on Normal distribution) :

a)Z-tests for population means : i) one sample and two sample tests for one-sided and two-sided alternatives, ii) 100(1- α)% two sided confidence interval for population mean (μ) and difference of means ($\mu_1 - \mu_2$) of two independent normal populations.

b)Z-tests for population proportions (Using central limit theorem) : i) one sample and two sample tests for one-sided and two-sided alternatives, ii) 100(1- α)% two sided confidence interval for

population proportion (P) and difference of proportions ($P_1 - P_2$) of two independent normal populations.

5.2 Tests based on chi-square distribution:

a) Test for independence of two attributes arranged in 2×2 contingency table. (With Yates' correction). (Problems are not expected)

b) Test for independence of two attributes arranged in r×s contingency table, McNemar's test (Problems are not expected)

c) Test for 'Goodness of Fit'. (Without rounding-off the expected frequencies). (Problems are not expected)

d) Test for $H_0 : \sigma^2 = \sigma_0^2$ against one-sided and two-sided alternatives when i) mean is known, ii) mean is unknown.

5.3 Tests based on t-distribution:

a) t-tests for population means : i) one sample and two sample tests for one-sided and two-sided alternatives, ii) 100(1- α)% two sided confidence interval for population mean (μ) and difference of means ($\mu_1 - \mu_2$) of two independent normal populations.

b) Paired t-test for one-sided and two-sided alternatives.

5.4 Test based on F-distribution:

a) Test for $H_0 : \sigma_1^2 = \sigma_2^2$ against one-sided and two-sided alternatives when i) means are known, ii) means are unknown.

Books Recommended:

1. Barlow R. E. and Proschan Frank: Statistical Theory of Reliability and Life Testing. Holt Rinebart and Winston Inc., New Yark.
2. Sinha S. K.: Reliability and Life Testing, Second Edition, Wiley Eastern Publishers, New Delhi.
3. Parimal Mukhopadhyaya: An Introduction to the Theory of Probability. World Scientific Publishing.
4. Hogg R.V., Criag A.T.: Introduction to Mathematical Statistics (3rd edition), Macmillan Publishing, New York.
5. Gupta S. C. &Kapoor V.K: Fundamentals of Mathematical Statistics. Sultan Chand & sons, New Delhi.

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

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

PO1: Disciplinary Knowledge

CO1: Understand Chi-Square distribution, Student's t-distribution, Snedecor's F distribution.

Weitage: 3 (Strongly Related)

Justification: PO1 focuses on disciplinary knowledge, and CO1 directly aligns with this by emphasizing the understanding of key probability distributions commonly used in statistical analysis.

CO2: Compute means, mode, variance, moments, cumulants for above Distributions.

Weitage: 3 (Strongly Related)

Justification: This objective involves practical aspects of computing statistical measures for various distributions, which contributes directly to disciplinary knowledge.

CO3: Apply Exact Sampling Distributions.

Weitage: 3 (Strongly Related)

Justification: Understanding and applying exact sampling distributions is a crucial aspect of disciplinary knowledge in statistics.

CO4: Know the relations among the different distributions.

Weitage: 2 (Moderately Related)

Justification: While understanding relationships among distributions is important, it is not as central to disciplinary knowledge as direct comprehension and computation of distributions.

CO5: Understand fundamental statistical concepts, including null hypothesis, alternative hypothesis, significance level, p-value, and Type I and Type II errors.

Weitage: 3 (Strongly Related)

Justification: This objective directly addresses fundamental statistical concepts, which are essential components of disciplinary knowledge.

CO6: Learn to apply testing of hypothesis in real-life situations.

Weitage: 3 (Strongly Related)

Justification: The practical application of hypothesis testing in real-life situations is a key aspect of disciplinary knowledge.

CO7: Demonstrate the ability to use statistical reasoning in decision-making processes.

Weitage: 3 (Strongly Related)

Justification: Using statistical reasoning in decision-making aligns directly with the application of disciplinary knowledge in practical scenarios.

PO2: Critical Thinking and Problem Solving

All COs contribute to critical thinking and problem-solving skills.

Weitage: 3 (Strongly Related)

Justification: Understanding, computing, and applying statistical concepts require critical thinking and problem-solving skills.

PO3: Social Competence Exhibit thoughts and ideas effectively in writing and orally

All COs contribute indirectly to social competence.

Weitage: 1 (Partially Related)

Justification: While statistical knowledge is valuable for effective communication, the direct focus of these objectives is on technical skills rather than social competence.

PO4: Research-Related Skills

All COs contribute to research-related skills.

Weitage: 3 (Strongly Related)

Justification: Competence in statistical concepts is essential for conducting research effectively.

PO5: Personal and Professional Competence

All COs contribute to personal and professional competence.

Weitage: 3 (Strongly Related)

Justification: Statistical knowledge is a foundational element for professional competence, especially in fields where data analysis is critical.

PO6: Effective Citizenship and Ethics

All COs contribute indirectly to effective citizenship and ethics.

Weitage: 1 (Partially Related)

Justification: While an understanding of statistics is important for informed decision-making, the direct focus of these objectives is on technical skills rather than ethical considerations.

PO8: Self-directed and Life-long Learning

All COs contribute to self-directed and life-long learning.

Weitage: 3 (Strongly Related)

Justification: Learning statistical concepts is foundational for ongoing professional development and adaptability.

PO9: Trans-disciplinary Research Competence

All COs contribute to trans-disciplinary research competence.

Weitage: 3 (Strongly Related)

Justification: Statistical knowledge is applicable across various disciplines, enhancing research competence in diverse fields.

SYLLABUS(CBCS) FOR S. Y. B. Sc. STATISTICS (w.e. from June, 2020)
(2019 Pattern)
Academic Year 2020-2021

Class : **S.Y. B. Sc. (Semester- IV)**
Paper Code: **STAT2403**
Paper : **III** Title of Paper : Statistics Practical-II

Credit : 2credits

Course Outcomes

By the end of course students are expected to be able to:

CO1. To compute multiple and partial correlation coefficients, to fit trivariate multiple regression plane, to find residual s. s. and adjusted residual s. s. (using R-software)
CO2. Compute the expected frequencies and test the goodness of fit.
CO3. Apply Chebeshev's Inequality for various distributions
CO4. Construct Control charts for Attributes and variables.
CO5. Analyze practical situations using statistical tests for various population parameters.
CO6. Project helps students to apply various statistical techniques on data collected by them.
CO7. Demonstrate the ability to use statistical reasoning in decision-making processes.

Sr. No.	Title of the experiment
1.	Construction Of Variable Control Charts($\bar{X}$, $and\ R\ Chrts$)
2.	Construction Of Attribute Control Charts(p-chart and c-chart)
3.	Test for means and proportions based on normal distribution using R Software.
4.	Test based on t and F distributions using R Software.
5.	Tests based on chi-square distribution (Independence of attributes and Goodness of fit test) using R Software.
6.	Fitting of multiple regression plane and computation of multiple and partial correlation coefficients using R Software.
7.	Computations of probabilities of distributions using R Software.
8.	Project (Project is equivalent to five practicals.)

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

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

PO1: Disciplinary Knowledge

CO1: To compute multiple and partial correlation coefficients, to fit trivariate multiple regression plane, to find residual s. s. and adjusted residual s. s. (using R-software).
Mapping: 3 (Strongly related)
Justification: This directly contributes to disciplinary knowledge by involving advanced statistical techniques like multiple and partial correlation coefficients, regression analysis, and using statistical software.

CO2: Compute the expected frequencies and test the goodness of fit.
Mapping: 3 (Strongly related)
Justification: Understanding and testing the goodness of fit is a fundamental concept in statistical inference, contributing to disciplinary knowledge.

CO3: Apply Chebyshev's Inequality for various distributions.
Mapping: 3 (Strongly related)
Justification: Applying Chebyshev's Inequality involves understanding and applying probability distributions, enhancing disciplinary knowledge in statistics.

CO4: Construct Control charts for Attributes and variables.

Mapping: 3 (Strongly related)
Justification: Constructing control charts is a core skill in quality control and statistical process control, contributing directly to disciplinary knowledge.

CO5: Analyze practical situations using statistical tests for various population parameters.
Mapping: 3 (Strongly related)
Justification: The application of statistical tests for population parameters is a key aspect of disciplinary knowledge in inferential statistics.

CO6: Project helps students to apply various statistical techniques on data collected by them.
Mapping: 3 (Strongly related)
Justification: Applied research involving the application of statistical techniques to real-

world data enhances research-related skills.

CO7: Demonstrate the ability to use statistical reasoning in decision-making processes.
Weitage: 3 (Strongly Related)
Justification: Using statistical reasoning in decision-making aligns directly with the application of disciplinary knowledge in practical scenarios.

PO2: Critical Thinking and Problem Solving
All COs contribute significantly to critical thinking and problem-solving skills by involving complex statistical techniques and applications.
Mapping: 3 (Strongly related)
Justification: Each CO requires critical thinking and problem-solving skills in the context of advanced statistical methods.

PO3: Social Competence Exhibit thoughts and ideas effectively in writing and orally
All COs contribute to effective communication of statistical concepts and findings, enhancing social competence.
Mapping: 3 (Strongly related)
Justification: The ability to apply statistical techniques and communicate findings effectively contributes to social competence.

PO4: Research-Related Skills
CO6: Project helps students to apply various statistical techniques on data collected by them.
Mapping: 3 (Strongly related)
Justification: Applied research involving the application of statistical techniques to real-world data enhances research-related skills.

PO5: Personal and Professional Competence
All COs contribute to personal and professional competence by providing a strong foundation in advanced statistical methods relevant to various professions.
Mapping: 3 (Strongly related)
Justification: The knowledge gained from these COs is directly applicable to various professions, enhancing personal and professional competence.

PO6: Effective Citizenship and Ethics
All COs involve ethical considerations in statistical analysis and decision-making, contributing to effective citizenship and ethics.
Mapping: 3 (Strongly related)
Justification: Ethical considerations are integral to the application of statistical techniques and decision-making.

PO7: Environment and Sustainability
No direct mapping observed. Statistical methods could indirectly contribute to environmental and sustainability studies through data analysis in relevant contexts.
Mapping: 1 (Partially related)

PO8: Self-directed and Life-long learning
All COs contribute to self-directed and life-long learning by providing a strong foundation in advanced statistical methods, enabling students to expand their knowledge independently.

Mapping: 3 (Strongly related)
Justification: Theoretical foundations provided by these COs empower students for continuous learning and skill development in statistics.

PO9: Trans-disciplinary Research Competence
No direct mapping observed. However, advanced statistical techniques could be applied in trans-disciplinary research contexts.
Mapping: 2 (Moderately related)
Justification: The application of statistical techniques in diverse research contexts could contribute to trans-disciplinary research competence.