Anekant Education Society's
Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati
Autonomous
Course Structure for T. Y. B. Sc. STATISTICS
2022 Pattern
(w. e. from Academic Year, 2024-25)

Semester	Paper Code	Title of Paper	No. of Credits
V	USST351	Distribution Theory	3
	USST352	Statistical Inference- I	3
	USST353	Sampling Methods	3
	USST354	Design of Experiments	3
	USST355	C- Programming	3
	USST356(A) USST356(B)	Introduction to Stochastic Processes Or Biostatistics	3
	USST357	Statistics Practical- V	2
	USST358	Statistics Practical- VI	2
	USST359	Statistics Practical- VII	2
VI	USST361	Introduction to Regression Analysis	3
	USST362	Statistical Inference- II	3
	USST363	Statistical Quality Control and Reliability	3
	USST364	Operations Research	3
	USST365	Statistical Computing Using R- Software	3
	USST366(A) USST366(B)	Official Statistics Or Actuarial Statistics	3
	USST367	Statistics Practical- VIII	2
	USST368	Statistics Practical- IX	2
	USST369	Project	2

Note:

Paper Code	Title of Paper	Practical Based on Paper
USST357	Statistics Practical- V	Design of Experiments
USST358	Statistics Practical- VI	Distribution Theory, Statistical Inference- I and Sampling Methods
USST359	Statistics Practical- VII	C- Programming
USST367	Statistics Practical- VIII	Introduction to Regression Analysis and Operations Research
USST368	Statistics Practical- IX	Statistical Inference- II and Statistical Quality Control and Reliability
USST369	Project	Project

Program Outcomes (POs) for B.Sc Programme

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 T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code : USST351
Paper : I Title of Paper : Distribution Theory
Credit : 3 credits No. of lectures : 48

A) Learning Objectives:

1. To learn how to apply continuous probability distribution to various business problems.
2. To provide a through theoretical grounding in different type of distributions.
3. To train students with essential tools for statistical analysis understanding through real-world of statistical applications.
4. To present the general theory of statistical distributions as well as the standard distributions found in statistical practice.
5. To learn general strategies for problems about order statistics and applications of order statistics.
6. To investigate applications of the Weibull distribution in analyzing failure rates, lifetime data, and time-to-event data.
7. To understand the concept of order statistics and their role in statistical inference.

B) Course Outcomes :

Students should be able to:

CO 1. define and understand fundamental concepts of probability, including sample space, events, and probability measures.

CO 2. develop problem solving techniques needed to calculate probabilities.

CO 3. understand the most common continuous probability distributions and their real-life applications.

CO 4. understanding of distribution helps to understand the nature of data and to perform appropriate analysis.

CO 5. the paper shall expose the students to different aspects of distribution theory. On studying this paper students can get to learn the theory underlying the construction of these distributions.

CO 6. thoroughly understanding the procedures of probability distributions students can apply these distributions to model random events.

CO 7. on studying the theory of order statistics students can learn how to model product failure, droughts, floods and other extreme occurrences.

TOPICS/CONTENTS:

Unit - 1. Beta Distribution **(9 L)**

1.1 Beta distribution of first kind: p.d.f

$$f(x) = \frac{1}{B(m,n)}\, x^{m-1}(1-x)^{n-1}, \qquad 0 \le x \le 1, \qquad m,n > 0$$

$$= 0, \qquad elsewhere$$

Notation: $X \sim \beta_1(m,n)$, Nature of probability curve, Derivation of mean, variance, r[th] raw moment, harmonic mean, mode, symmetry of the distribution.

1.2 Relation with U (0, 1), probability distributions of $\frac{1}{X}, X+Y, X-Y, XY, \frac{X}{Y}$, where X and Y are iid $\beta_1(1,1)$

1.3 Beta distribution of second kind: p.d.f. $f(x) = \frac{1}{B(m,n)} \frac{x^{m-1}}{(1-x)^{m+n}} \quad ; x \ge 0,\ m,n > 0$

$$= 0 \qquad ; elsewhere$$

Notation: $X \sim \beta_2(m,n)$, Nature of probability curve, Derivation of mean, variance, r[th] raw moment, harmonic mean, mode, symmetry of the distribution.

1.4 Derivation of interrelation between $\beta_1(m,n)$ and $\beta_2(m,n)$

1.5 Derivation of distribution of $\frac{X}{Y}, \frac{X}{X+Y}$, where X and Y are independent gamma variates.

1.6 Statement of relation between distribution function of $\beta_1(m,n)$ and binomial distribution.

1.7 Illustrative examples.

Unit – 2 Weibull Distribution **(4 L)**

2.1 p.d.f . $f(x) = \frac{\beta}{\alpha}\left(\frac{x}{\alpha}\right)^{\beta-1} exp\left\{-\left(\frac{x}{\alpha}\right)^{\beta}\right\} \ ; x \ge 0, \alpha, \beta > 0$

$$= 0 \qquad ; elsewhere$$

Notation X ~ W (α, β)

2.2 Probability curve, location parameter, shape parameter, scale parameter. Derivation of distribution function, quartiles, mean and variance, coefficient of variation, relationship with gamma and exponential distribution.

2.3 Illustrative examples.

Unit – 3 Pareto Distribution **(4 L)**

3.1 p.d.f. with parameters (α, β) $f(x) = \frac{\alpha\beta^{\alpha}}{x^{\alpha+1}}$ $; x \geq \beta \text{ and } \alpha, \beta > 0,$

$= 0$ $; elsewhere$

Notation X ~ Pareto (α, β)

3.2 Probability curve, shape parameter, scale parameter.

3.3 Derivation of distribution function, quartiles, mean, variance, mode, skewness.

3.4 Relationship with exponential distribution, applications.

3.5 Illustrative examples.

Unit – 4 Order Statistics **(5 L)**

4.1 Order Statistics for a random sample of size n from a continuous distribution, definition, derivation of distribution function and density function of the i^{th} order statistics $X_{(i)}$, particular cases for $X_{(1)}$ and $X_{(n)}$.

4.2 Distribution of $X_{(i)}$ for a random sample from uniform and exponential distribution.

4.3 Joint distribution of r^{th} and s^{th} order statistic $(X_{(r)}, X_{(s)})$ for a random sample from uniform and exponential distribution.

4.3 Distribution of sample median for a random sample from uniform distribution.

4.4 Distribution of sample range

4.5 Illustrative examples.

Unit – 5 Cauchy Distribution **(5 L)**

5.1 p.d.f. $f(x) = \frac{\lambda}{\pi} \frac{1}{\lambda^2+(x-\mu)^2}; -\infty < x < \infty, -\infty < \mu < \infty, \lambda > 0.$

$= 0$ $; elsewhere$

Notation: X ~ C (μ, λ)

5.2 Nature of the probability curve, comparison with tails of normal distribution.

5.3 Derivation of distribution function, quartiles, non – existence of moments, statement of distribution of ɑX + b, derivation of distribution of i) $\frac{1}{x}$ ii) X^2 where X~ C (0,1), problems based on these results.

5.4 Statement of additive property for two independent Cauchy variates, statement of distribution of the sample mean, comment on limiting distribution of X.

5.5 Statement of relationship with uniform, Student's t and normal distributions.

5.6 Illustrative examples.

Unit – 6 Laplace (Double Exponential) Distribution **(5 L)**

6.1 p.d.f. $f(x) = \frac{\lambda}{2}\, exp(-\lambda|x-\mu|)\ ;\ -\infty < x < \infty, -\infty < \mu < \infty, \lambda > 0.$

$= 0 \qquad\qquad ; elsewhere$

Notation: X~ L (μ , λ)

6.2 Nature of the probability curve.

6.3 Derivation of distribution function, quartiles.

6.4 MGF, CGF, Moments and cumulants, skewness and kurtosis.

6.5 Derivation of Laplace distribution as the distribution of the difference of two i.i.d. exponential random variables with mean $\frac{1}{\lambda}$.

6.6 Illustrative examples.

Unit –7. **Lognormal Distribution** **(7 L)**

7.1 p.d.f. $f(x) = \frac{1}{(x-a)\sigma\sqrt{2\pi}} exp\left\{\frac{-1}{2\sigma}[log_e(x-a)-\mu]^2\right\} \quad ; x > a, -\infty < \mu < \infty, \sigma > 0,$

$= 0 \qquad\qquad ; elsewhere$

Notation: X~ LN (a, μ, σ^2)

7.2 Derivation of relation with N (μ, σ²) distribution

7.3 Nature of the probability curve.

7.4 Derivation of moments (r-th moment of X-a), mean, variance, quartile, mode, Karl Pearson's and Bowley's coefficient of skewness and kurtosis, derivation of quartiles and mode.

7.5 Distribution of $(\prod x_i)$, when X_i's independent lognormal random variables.

7.6 Illustrative examples.

Unit – 8. Bivariate Normal Distribution **(9L)**

8.1 p.d.f of a bivariate normal distribution.

$$f(x) = \frac{1}{2\pi\sigma_1\sigma_2\sqrt{1-\rho^2}}\, exp\left\{\frac{-1}{2(1-\rho^2)}\left[\left(\frac{x-\mu_1}{\sigma_1}\right)^2 + \left(\frac{y-\mu_2}{\sigma_2}\right)^2 - 2\rho\left(\frac{x-\mu_1}{\sigma_1}\right)\left(\frac{y-\mu_2}{\sigma_2}\right)\right]\right\};$$

$$; -\infty < x, y < \infty,\ -\infty < \mu_1, \mu_2 < \infty\ \ \sigma_1, \sigma_2 > 0, -1 < \rho < 1$$

Notation (X, Y) ~BN $(\mu_1, \mu_2, \sigma_1, \sigma_2, \rho)$

8.2 Nature of surface of p.d.f., marginal and conditional distributions, identification of parameters, regression of Y on X, independence and uncorrelatedness, Derivation of MGF and moments. Statement of distribution of aX+ bY+ c and distribution of $\frac{X}{Y}$.

8.3 Illustrative examples.

Books Recommended

1. Arora Sanjay and Bansi Lal (1989). Mathematical Statistics (1st Edition), Satya Prakashan 16/17698, New Delhi.
2. Cramer H.: (1962) Mathematical Method of Statistics, Asia Publishing House, Mumbai
3. Gupta S. C. and Kapoor V. K.: (2006). Fundamental Mathematical Statistics, Sultan Chand and Sons, 88, Daryaganj, New Delhi.
4. Hogg, R.V. and Craig A. T. (1970). Introduction Mathematical Statistics (IIIrd Edition), Macmillan Publishing Company. Inc. New York
5. Lindgren B.W.: (1976) Statistical Theory (IIIrd Edition) Collier Macmillan international Edition, Macmillan Publishing Co. Inc. New York.
6. Mood. A.M., Graybill, F. Bose, D. C.: (1974) Introduction to theory of Statistics. (IIIrd Edition) Mc- Graw Hill Series.
7. Mukhopdhyay, P (1996). Mathematical Statistics, New Central Book Agency.
8. Rohatgi, V. K. (1975) An Introduction to probability Theory and Mathematical Statistics, Wiley Eastern Ltd. New Delhi
9. Feller, W.: An introduction of Probability Theory and its applications, Wiley Eastern Ltd. Mumbai.
10. Jhonson and Kotz: Continuous Univariate Distributions I and II: Discrete distributions.
11. Bhat B. R.: Modern Probability Theory, New Age International.

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Building basic programs, understanding SQL, and working with Python demonstrate comprehensive knowledge in programming.

PO2: Critical Thinking and Problem Solving

CO2: Work with user input to create fun and interactive programs.

Justification: Moderately Related (2) - Creating interactive programs requires critical thinking about user needs and preferences.

PO3: Social Competence

CO2: Work with user input to create fun and interactive programs.

Justification: Partially Related (1) - While the focus is on technical skills, creating interactive programs involves considering user experience, aligning with social competence.

PO4: Research-related Skills and Scientific Temper

All Course Outcomes are Strongly Related (3) - Building a sense of inquiry, formulating hypotheses, and working with databases align with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

CO6: Connect Python to SQL databases, execute queries, and retrieve results.

Justification: Moderately Related (2) - Connecting Python to databases involves integration across different technologies, contributing to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Strongly Related (3) - Performing independently, collaborating in teams, and committing to professional ethics are inherent in programming skills.

PO7: Effective Citizenship and Ethics

All Course Outcomes are Strongly Related (3) - Demonstrating empathy, social concern, and acting with an awareness of moral and ethical issues align with ethical considerations in programming.

PO8: Environment and Sustainability

Co5: Justification: Partially Related (1) - While the focus is on Environment and Sustainability

PO9: Self-directed and Life-long Learning

All Course Outcomes are Strongly Related (3) - Acquiring the ability to engage in independent and life-long learning is inherent in programming skills and keeping up with evolving technologies.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code	: USST352		
Paper	: II	Title of Paper	: Statistical Inference- I
Credit	: 3 credits	No. of lectures	: 48

A) Learning Objectives:

The main objective of this course is to get knowledge about

1. The concept of estimation of parameters.
2. Notion of parameter and estimator.
3. Applying various methods of estimation.
4. Important inferential aspects such as point estimation and interval estimation.
5. Properties of a good estimator.
6. Explain the method of moments and derive moment estimators for standard distributions.
7. Efficient estimator through relative efficiency, MVUE, UMVUE and MVBUE.

B) Course Outcomes :

After completing this course, students will possess skills concerning:

CO 1. Learn point estimation methods, including calculating and interpreting sample means, sample proportions, and other estimators.

CO 2. Understand the concept of point estimation and how it differs from interval estimation.

CO 3. Gain knowledge of maximum likelihood estimation principles, including likelihood function, log-likelihood function, and methods for obtaining estimators.

CO 4. Estimation, Parameter, statistic, standard error, sampling distribution of a statistic,

CO 5. Characteristics of a good estimator

CO 6. Different methods of estimation

CO 7. Understand the efficiency of an estimator in terms of its precision and variability, and learn to compare the efficiencies of different estimators.

TOPICS/CONTENTS:

Unit 1: Point Estimation **(4 L)**

1.1 Notion of a parameter, parameter space, sample space as a set of all

possible values of (X_1, X_2, . . , X_n),general problem of estimating an unknown parameter by point and interval estimation.

1.2 Point Estimation: Definition of an estimator, distinction between estimator and estimate, illustrative examples.

1.3 Mean Square Error (MSE) of an estimator.

Unit 2: Methods of Estimation **(10 L)**

2.1 Method of moments: Derivation of moment estimators for standard distributions. Illustrations of situations where M.L.E. and moment estimators are distinct and their comparison using mean square error. Examples and problems.

2.2 Method of maximum likelihood:

2.2.1: Definition of likelihood as a function of unknown parameter, for a random sample from i) discrete distribution ii) continuous distribution. Examples and problems.

2.2.2: Derivation of maximum likelihood estimator (M.L.E.) for parameters of only standard distributions (case of two unknown parameters only for normal distribution).

2.2.3: M.L.E. of θ in uniform distribution over i) $(0, \theta)$ ii) $(-\theta, \theta)$ iii) $(m\theta, n\theta)$ $(m < n)$

2.2.4: M.L.E. of θ in $f(x ; \theta) = \text{Exp}\{-(x- \theta)\}$, $x > \theta$.

2.2.5: M.L.E. of location parameter in Laplace distribution.

2.2.6: Invariance property of M.L.E.

Unit 3: Properties of Estimators

7.1 Unbiasedness **(4 L)**

Definition of an unbiased estimator, biased estimator, positive and negative bias, illustrations and examples. Proofs of the following results regarding unbiased estimators:

(a) Two distinct unbiased estimators of θ give rise to infinitely many estimators.

(b) If T is an unbiased estimator of θ, then ϕ (T) is unbiased estimator of ϕ (θ) provided ϕ (.) is a linear function.

7.2 Efficiency **(4 L)**

Relative efficiency of unbiased estimator T_1 with respect to another unbiased

estimator T_2, use of mean square error to define relative efficiency of biased estimators, Notion of the Best Linear Unbiased Estimator and Uniformly Minimum Variance Unbiased Estimator (UMVUE), uniqueness of UMVUE whenever it exists, Examples and problems.

7.3 Sufficiency (7 L)

Concept and definition of sufficiency, statement of the Fisher-Neyman factorization theorem with proof for discrete probability distribution. Pitmann – Koopman form and sufficient statistic; Exponential family of probability distributions and sufficient statistic. Examples and problems. Proofs of the following properties of sufficient statistics:

(a) If T is sufficient for θ, then ø (T) is also sufficient for θ provided ø is a one to one and onto function.

(b) If T is sufficient for θ then T is also sufficient for ø (θ).

(c) M.L.E. is a function of sufficient statistic.

7.4 Asymptotic Behavior of an Estimator (6 L)

Chebychev's inequality for discrete and continuous distributions. Consistency: Definition. Proof of the following theorems:

(a) An estimator is consistent if its bias and variance both tend to zero as the sample size tends to infinity.

(b) If T is consistent estimator of θ and ø (.) is a continuous function, then ø (T) is a consistent estimator of ø (θ)

Examples and problems.

Unit 4: Cramer- Rao Inequality (7 L)

8.1 Fisher information function: Amount of information contained in statistic T = $T(X_1, X_2, \ldots, X_n)$. Statement regarding information in sample and in a sufficient statistic T.

8.2 Cramer- Rao Inequality

4.2.1: Statement and proof of Cramer - Rao inequality, Cramer – Rao Lower Bound (CRLB), definition of minimum variance bound unbiased estimator (MVBUE) of ø (θ). Examples and problems.

4.2.2: Proofs of following results:

(a) If MVBUE exists for θ then MVBUE exists for ø (θ) where ø (.) is a linear function.

(b) If T is MVBUE for θ then T is sufficient for θ.

4.2.3: Comparison of variance with CRLB, relative efficiency of T_1 w. r. t. T_2 for (i) unbiased (ii) biased estimators. Efficiency of unbiased estimator T w. r. t. CRLB.

Unit 5: Interval Estimation **(6 L)**

9.1 Notion of interval estimation, definition of confidence interval (C.I), length of C.I., Confidence bounds, confidence coefficient. Definition of pivotal quantity and its use in obtaining confidence intervals.

9.2 Interval estimation for the following cases:

i) Mean (μ) of normal distribution (when σ^2 known and σ^2 unknown).

ii) Variance (σ^2) of normal distribution (when μ known and μ unknown).

iii) Median, quartiles using order statistics.

Books Recommended

1. Kale B. K. and Murlidharan K. (2015) Introduction to Parametric Inference, Narosa Publication House, New Delhi.
2. Rohatagi, V. K. (1975) An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.
3. Lehman E. L. (1988) Theory of point estimation (John Wiley)
4. Dudeweitz, E. J. and Mishra, S. N. (1988) Modern Mathematical Statistics, John Wiley and Sons, Inc.
5. Hoel, P. G. Port, S. and Stone, C. (1972) Introduction to Statistical Theory, Houghton Mifflin Company (International) Dolphin Edition.
6. Hogg, R. V. and Craig, A. T. (1978) Introduction to Mathematical Statistics (fourth edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc., New York
7. Kendall, M. and Stuart, A. (1943) The advanced Theory of Statistics, Vol- 1, Charles and Company Ltd., London
8. Lindgren, B. W. (1976) Statistical Theory (third edition) Collier Macmillan International Edition, Macmillan Publishing Co., Inc. New York
9. Mood, A. M., Graybill, F. and Bose, D. C. (1974). Introduction to the theory of Statistics (third edition) International Student Edition, McGraw Hill.
10. Ramchandran, K. M. and Tsokos C. P. (2009). Mathematical Statistics with Applications, Academic Press.

11. Casella G. and Berger R. L. (2001) Statistical Inference, 2nd edition, Duxbury press.

12. Mukhopadhyay, N. (2020) Probability and Statistical inference. CRC Press.

13. Dixit, U. J. (2016) Examples in Parametric Inference with R. Singapore: Springer.

14. Fergusson T. S. (1996) Mathematical Statistics.

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Learning point estimation methods and understanding the concept of point estimation contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Moderately to Strongly Related (2-3) - Critical thinking is involved in understanding and interpreting point estimation methods and different estimation principles.

PO3: Social Competence

All Course Outcomes are Moderately Related (2) - While understanding point estimation principles may not directly relate to social competence, effective communication of statistical concepts could contribute.

PO4: Research-related Skills and Scientific Temper

All Course Outcomes are Moderately to Strongly Related (2-3) - Understanding and applying maximum likelihood estimation principles align with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

All Course Outcomes are Moderately to Strongly Related (2-3) - Integrating different estimation methods and principles contributes to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Strongly Related (3) - Performing independently and

collaboratively in understanding and applying point estimation methods aligns with personal and professional competence.

PO7: Effective Citizenship and Ethics

All Course Outcomes are Moderately Related (2) - Understanding statistical estimation may not directly relate to citizenship and ethics, but awareness of ethical considerations in research is implied.

PO8: Environment and Sustainability

CO4: Estimation, Parameter, statistic, standard error, sampling distribution of a statistic

Justification: Partially Related (1) - While understanding estimation concepts is fundamental, the direct connection to environmental and sustainability aspects is limited.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Moderately to Strongly Related (2-3) - Acquiring the ability to engage in independent and life-long learning is inherent in understanding and applying statistical estimation concepts.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code	: USST353		
Paper	: III	Title of Paper	: Sampling Methods
Credit	: 3 Credits	No. of lectures	: 48

A) Learning Objectives:

1. Describe the situations where and how to use probability sampling methods
2. Estimating population parameters using sampling distribution of estimator and obtaining estimators of standard error in estimation under various sampling procedures.
3. Determining adequate sample size for various sampling procedures.
4. Explore the use of sampling methods in survey research and experimental design.
5. Describe the concept of sampling error and non-sampling error.
6. Explain when non-probability sampling methods may be preferred.
7. Explore methods for estimating population parameters and their precision.

B) Course Outcomes:

CO 1. Identify and recognize the appropriate sample survey design for related problems.

CO 2. Understand the importance of sampling and how results from samples can be used to provide estimates of population characteristics such as the population mean, the population standard deviation and / or the population proportion.

CO 3. Estimates the convenient sample size for Simple random sampling and stratified random sampling.

CO 4. Have an appreciation of the practical issues arising in sampling studies.

CO 5. Understand the concept of sampling error and its implications for the accuracy of sample estimates.

CO 6. Study non-probability sampling methods and their applications, recognizing their limitations and biases.

CO 7. Understand the principles of systematic sampling and learn how to implement this method in practice.

TOPICS/CONTENTS:

Unit-1. Sampling **(8 L)**

1.1 Concept of distinguishable elementary units, sampling units, sampling frame, random sample, requisites of a good sample. Simple random sampling from finite population of size (N) (i) with replacement (SRSWR) ii) without replacement (SRSWOR) definitions, population mean and population total as parameters, inclusion probabilities.

1.2 (a) Sample mean $\bar{y}$ as an estimator of population mean, derivation of expectation and standard error of $\bar{y}$, confidence interval for population mean, population total standard error.

(b) $N\bar{y}$ as an estimator of population total, derivation of expectation and standard error of $N\bar{y}$ (c) Estimator of above standard errors, both in case of SRSWR and SRSWOR.

1.3 Sampling for proportion as an application of a simple random sampling with X_i as zero or one.

(a) sample proportion as an estimator of population proportion of units possessing a certain attribute, derivation of expectation and standard error of (p).

(b) N_p as an estimator of total number of units in the population possessing a certain attribute, derivation of expectation and standard error of N_p

(c) Estimator of above standard error both in case of SRSWR and SRSWOR.

Unit-2. Determination of Sample Size (in case of SRS) **(4 L)**

2.1 Determination of the sample size for the given:

(a) Margin of error and confidence coefficient.

(b) Coefficient of variation of the estimator and confidence coefficient.

Unit-3. Stratified Random Sampling **(12 L)**

3.1 Stratification, basis of stratification, real life situation where stratification can be used.

3.2 Stratified random sampling as a sample drawn from individual strata using SRSWOR in each stratum.

3.3 (a) $\overline{y_{st}} = \frac{\sum N_i \bar{y}_i}{N}$ as an estimator of population mean ($\bar{Y}$), Derivation of expectation and standard error of $\overline{y_{st}}$.

(b) N $\overline{y_{st}}$ as an estimator of population total, derivation of expectation and standard

error of $N\overline{y_{st}}$.

(c) Estimator of above standard errors.

3.4 Problem of allocation, proportional allocation, Neyman's allocation, derivation of the expressions for the standard errors of the above estimators when these allocations are used.

3.5 Gain in precision due to stratification, comparison amongst SRSWOR, stratification with proportional allocation and stratification with Neyman's allocation.

3.6 Cost and variance analysis in stratified random sampling, minimization of variance for fixed cost, minimization of cost for fixed variance, optimum allocation, Neyman's allocation as a particular case of optimum allocation in cost and variance analysis.

Unit-4. Ratio and Regression Methods of Estimation for SRSWOR (Sampling Methods using Auxiliary variables) (6 L)

4.1 Rationale behind using auxiliary variates in estimation.

4.2 Situations where (a) ratio method is appropriate, (b) regression method is appropriate.

4.3 Ratio and regression estimators of the population mean and population total.

4.4 Comments regarding bias, statement of standard errors of ratio and regression estimators relative efficiency of these estimators, with respect to SRSWOR. (Derivations are not expected).

Unit-5. Systematic Sampling (Linear Systematic Sampling) (6 L)

5.1 Real life situations where systematic sampling is appropriate. Techniques of drawing a sample using systematic sampling.

5.2 Estimation of the population mean and population total, standard error of these estimators.

5.3 Comparison of systematic sampling with SRSWOR.

5.4 Comparison of systematic sampling with SRSWOR and stratified sampling in the presence of linear trend.

Unit-6. Role of Sample Surveys in Research Methodology (8 L)

6.1 Objectives of a sample survey.

6.2 Designing a questionnaire, characteristics of a good questionnaire (Questions with codes & scores are to be discussed). Reliability and validity testing by using

(a) Test – Retest method

(b) Internal Consistency: (i) Kuder Rechardson Coefficient (KR-20)

(ii) Cronbach's Coefficient Alpha

6.3 Planning, execution and analysis of a sample survey, practical problems at each of these stages.

6.4 Sampling and non-sampling errors with illustrations.

6.5 Study of some surveys illustrating the above ideas, rounds conducted by National Sample Surveys organization.

Unit-7. Non-probability sampling techniques (4 L)

7.1 Quota sampling, Convenience sampling, Purposive sampling and snowball sampling.

Books Recommended

1) Cochran, W. G. (1977) Sampling Techniques, third Edition Wiley Eastern Ltd., New Delhi.
2) Malhotra N. (2008) Marketing Research and Applied Orientation (third edition), Prentice Hall of India.
3) Mukhopadhyay P (2008) Sampling theory and methods of survey sampling. Prentice-Hall of India, New Delhi.
4) Murthy, M. N. (1967) Sampling methods, Indian Statistical Institute, Kolkata.
5) Singh, D. and Chaudhary, F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
6) Sukhatme, P. V., Sukhatme, B. V. (1984) Sampling theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Identifying appropriate sample survey

designs and understanding the importance of sampling contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Strongly Related (3) - Critical thinking is involved in recognizing appropriate sample survey designs, understanding the importance of sampling, and estimating sample sizes.

PO3: Social Competence

All Course Outcomes are Moderately Related (2) - While understanding sampling concepts may not directly relate to social competence, effective communication of statistical concepts could contribute.

PO4: Research-related Skills and Scientific Temper

All Course Outcomes are Moderately to Strongly Related (2-3) - Understanding and applying sampling methods align with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

All Course Outcomes are Moderately to Strongly Related (2-3) - Integrating different sampling methods and principles contributes to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Strongly Related (3) - Performing independently and collaboratively in understanding and applying sampling methods aligns with personal and professional competence.

PO7: Effective Citizenship and Ethics

All Course Outcomes are Moderately Related (2) - Understanding sampling methods may not directly relate to citizenship and ethics, but awareness of ethical considerations in research is implied.

PO8: Environment and Sustainability

CO4: Have an appreciation of the practical issues arising in sampling studies

Justification: Partially Related (1) - While understanding practical issues in sampling is fundamental, the direct connection to environmental and sustainability aspects is limited.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Strongly Related (3) - Acquiring the ability to engage in independent and life-long learning is inherent in understanding and applying sampling concepts.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code	: USST354		
Paper	: IV	Title of Paper	: Design of Experiments
Credit	: 3 credits	No. of lectures	: 48

A) Learning Objectives:

1. The main objective of this course is to learn and understand various designs of experiments.
2. Understand the fundamental principles and objectives of experimental design.
3. Explore the role of randomization, replication, and control in experimental design.
4. Explore the advantages and limitations of CRD, RBD, LSD and its applications in various fields.
5. Learn how to design and analyze factorial experiments with two or more factors.
6. Students should be able to identify the design, carryout various experiments and analyze the data.
7. Students should be able to apply appropriate design in real life situation.

B) Course Outcomes:

CO 1. Students will be able to understand basic principles and various terms of Design of Experiments.

CO 2. Students will be able to apply Factorial design, confounding in real life problems.

CO 3. Students should be able to analyze the data of various experimental design.

CO 4. Learn the concept of factorial experiments and understand how to design and analyze experiments with multiple factors.

CO 5. Learn about confounding in experimental designs.

CO 6. Develop a clear understanding of both ANOVA and regression analysis as ANOCOVA combines elements from both methodologies.

CO 7. Develop a clear understanding of the concept of efficiency in experimental design, including its importance in resource optimization.

TOPICS/CONTENTS:

Unit-1 Introduction (4 L)

1.1 Concept of Design of Experiment (DOE), Introduction to basic terms of Design of Experiments, Experimental unit, treatments, layout of an experiment, factor, level, run of experiment, control experiment, test experiment.

1.2 Basic principles of Design of Experiments, Randomization, Replication and Local control. 1.3 Uniformity trials.

1.4 Choice of size and shape of a plot.

1.5 The empirical formula for the variance per unit area of plots.

Unit-2 Standard Designs of Experiments (15 L)

2.1 Completely Randomized Design (CRD): Application of the principles of design of experiment in CRD, Layout of CRD, Model: $X_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ i = 1, 2, …, t; j = 1, 2, …., n_i assumptions and interpretations. Testing normality graphically. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of (ANOVA) table, testing equality of treatment effects, Hypothesis to be tested $H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_t = 0$. Comparison of treatment means using box plot techniques. Statement of Cochran's theorem. F test for testing H_0 with justification (independence of chi- square is to be assumed), test for equality of two specified treatment effects using critical difference (C.D). Merits and demerits of CRD.

2.2 Randomized Block Design (RBD): Application of the principles of design of experiments in RBD, layout of RBD, Model: $X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ i = 1, 2, …, t; j = 1, 2, …, b, Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, Hypotheses to be tested $H_{01} : \alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_t = 0$; $H_{02} : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_b = 0$. F test for testing H_{01} and H_{02} with justification (independence of chi-squares is to be assumed), test for equality of two specified treatment effects using critical difference (CD). Merits and demerits of RBD.

2.3 Latin Square Design (LSD): Application of the principles of design of experiments in LSD, layout of LSD, Model: $X_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$ i = 1, 2, ···, m; j = 1, 2, ···, m; k = 1, 2, ···, m. Assumptions and interpretations. Breakup of

total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, hypotheses to be tested. $H_{01} : \alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_m = 0$; $H_{02} : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_m = 0$; $H_{03} : \gamma_1 = \gamma_2 = \cdots = \gamma_m = 0$ and their interpretation. Justification of F test for H_{01}, H_{02} and H_{03} (independence of chi- square is to be assumed). Preparation of ANOVA table and F test for H_{01}, H_{02} and H_{03} testing for equality of two specified treatment effects, comparison of treatment effects using critical difference, linear treatment contrast and testing its significance. Merits and demerits of LSD.

2.4 Linear treatment contrasts, orthogonal contrasts. Scheffe's method for comparing contrasts, Tuckey's procedure for comparing pairs of treatment means (applicable to C.R.D., R.B.D. and L.S.D.)

2.5 Identification of real-life situations where the above designs are useful.

Unit-3 Analysis of non- normal data using **(5 L)**

3.1 Square root transformation for counts.

3.2 Sin^{-1} (.) transformation for proportions.

7.3 Kruskal Wallis test.

Unit-4 Efficiency of a Design **(5 L)**

4.1 Concept and definition of efficiency of a design.

4.2 Efficiency of RBD over CRD.

4.3 Efficiency LSD over CRD.

4.4 Efficiency LSD over RBD taking

i) Row as a Block.

ii) Column as a Block.

4.5 Simple numerical problems.

Unit-5 Analysis of Covariance (ANOCOVA) **(7 L)**

5.1 Situations where analysis of covariance is applicable.

5.2 Model for ANOCOVA in CRD and RBD with One Concomitant Variable. Estimation of parameters (derivations are not expected)

5.3 Preparation of analysis of variance – covariance table, test for $\beta = 0$, test for equality of treatment effects (computational technique only).

Unit-6 Factorial Experiments **(12 L)**

6.1 General description of m × n factorial experiment, 2^2 and 2^3 factorial experiments arranged in RBD.

6.2 Definitions of main effects and interaction effects in 2^2 and 2^3 factorial experiments.

6.3 Yate's procedure, preparation of ANOVA table, test for main effects and interaction effects.

6.4 General idea of confounding in factorial experiments.

6.5 Construction of layouts in total confounding and partial confounding in 2^2 and 2^3 factorial experiments.

6.6 Total confounding (confounding only one interaction) ANOVA table, testing main effects and interaction effects.

6.7 Partial confounding (confounding only one interaction per replicate); ANOVA table, testing main effects and interaction effects.

6.8 Construction of layouts in total confounding and partial confounding for 2^2, 2^3 factorial experiments.

Books Recommended

1. Cochran W. G. and Cox, C. M. (1968) Experimental Design, John Wiley and Sons, Inc., New York.
2. Dass, M. N. and Giri, N. C. (1986) Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi
3. Federer W. T. (1967) Experimental Design: Oxford and IBH Publishing Co., New Delhi
4. Goon, A.M., Gupta, M. K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pvt. Ltd. Kolkatta
5. Gupta S. C. and Kapoor V. K. (2006). Fundamentals of Applied Statistics, S. Chand Sons, New Delhi
6. Johnson, R. A., Miller, I. and Freund, J. (2010). Probability and Statistics for engineers, Prentice Hall, India.
7. Kempthorne, O. (1952). Design of Experiments, Wiley Eastern Ltd., New Delhi.
8. Montgomery, D. C. (2001). Design and Analysis of Experiments, John Wiley and sons Inc., New Delhi.

9. Snedecor, G. W. and Cochran, W. G. (1994). Statistical Methods, 8th edition, Affiliated East – West Press, New Delhi
10. Wu, C. F. J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc., Hoboken, New Jersey.

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Understanding basic principles, terms of Design of Experiments, and analyzing experimental designs contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Moderately to Strongly Related (2-3) - Applying factorial design, analyzing data, and understanding efficiency in experimental design involve critical thinking and problem-solving skills.

PO3: Social Competence

CO3: Students should be able to analyze the data of various experimental designs

Justification: Partially Related (1) - While data analysis is important, the direct link to social competence is limited.

PO4: Research-related Skills and Scientific Temper

All Course Outcomes are Moderately to Strongly Related (2-3) - Understanding and applying experimental design principles align with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

CO5: Learn about confounding in experimental designs

Justification: Partially Related (1) - While understanding confounding, it doesn't strongly contribute to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Moderately to Strongly Related (2-3) - Performing independently and collaboratively in understanding and applying experimental design aligns with personal and professional competence.

PO7: Effective Citizenship and Ethics

CO7: Develop a clear understanding of the concept of efficiency in experimental design, including its importance in resource optimization

Justification: Partially Related (1) - Efficiency in experimental design, while important, doesn't strongly connect to effective citizenship and ethics.

PO8: Environment and Sustainability

CO7: Develop a clear understanding of the concept of efficiency in experimental design, including its importance in resource optimization

Justification: Partially Related (1) - While efficiency is important, the direct connection to environmental and sustainability aspects is limited.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Strongly Related (3) - Acquiring the ability to understand and apply experimental design principles contributes to self-directed and life-long learning.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code	: USST355		
Paper	: V	Title of Paper	: C- Programming
Credit	: 3 credits	No. of lectures	: 48

A) Learning Objectives:

Students successfully completing this course will be able:

1. Understand the fundamentals of the C programming language.
2. Learn the basic syntax and structure of C programs.
3. Understand concepts such as variables, data types, and operators.
4. Learn how to declare, initialize, and access elements of arrays and pointers.
5. The course realizes and design algorithm for problem solving.
6. The objective of the course is to develop problem solving abilities using computers.
7. The student will develop skills for writing programs using C.

B) Course Outcomes:

CO 1. Student will be solved to problems using programming capability.

CO 2. Student will be exploring their algorithmic approaches to problem solving.

CO 3. Student will be developed modular programs using control structures, pointers, arrays, strings and functions.

CO 4. Explore the use of arrays and strings in C, including declaration, initialization, and manipulation of array elements and string characters.

CO 5. Learn the syntax and semantics of the C programming language, including rules for writing and structuring code.

CO 6. Understand various data types in C (integers, floats, characters, etc.) and how to use operators for arithmetic, relational, and logical operations.

CO 7. Learn how to perform input and output operations using standard functions like printf and scanf.

TOPIC CONTENT

Unit 1: C Fundamental **(12 L)**

1.1 History of ‘C’ language, Application areas, Structure of a ‘C’ program, ‘C’ Program development life cycle, Function as building blocks,

1.2 'C' tokens: Character set, Keywords, Identifiers, Variables, Constants (character, integer, float, string, escape sequences, enumeration constant),

1.3 Data Types: Numeric and character data types, Numeric and character constants, string constants, symbolic constants.

1.4 Operators, Types of operators: arithmetic, relational, logical, assignment, bitwise, conditional. Expressions, types of operators, Operator precedence and Order of evaluation.

1.5 Character input and output, String input and output, Formatted input and output.

Unit 2: Control Structure **(10 L)**

Decision making structures: - if, if-else, switch and conditional operator, Loop control structures: - while, do while, for, use of break and continue, Nested structures, Unconditional branching (goto statement)

Unit 3: Array **(10 L)**

Concept, declaration, definition, initialization of array, problem using arrays, passing to function.

List of programs using arrays.

3.1 To find mean, median, variance and coefficient of variation of frequency distribution.

3.2 To find correlation coefficient and least square regression line of Y on X for a given bivariate data.

3.3 To arrange the given data in increasing/decreasing order of magnitude.

3.4 To obtain median of given n observations.

3.5 To obtain addition of two matrices, multiplication of two matrices.

Unit 4: String **(4 L)**

String Literals, string variables, declaration, definition, initialization, Syntax and string operations, use of predefined string functions, string functions like strcpy(), strcat(), strlen(), strcmp(), strrev(). Array of strings.

Unit 5: Function **(8 L)**

Concept of function, Standard library functions, User defined functions: - declaration, definition, function call, parameter passing (by value), calling a function by reference and by value, return statement. Recursive functions, Scope of variables. local and global variables. List of writing functions:

1. To find factorial of integer number (both recursive and non-recursive)
2. To find the value of Xn where n is integer. (both recursive and non-recursive)
3. To find GCD of two integer numbers (both recursive and non-recursive)
4. To find maximum/minimum of n numbers. (non-recursive)

Unit 6: Pointer **(4 L)**

Introduction to Pointers. Declaration, definition, initialization, dereferencing. Pointer arithmetic. Relationship between Arrays & Pointers- Pointer to array, Array of pointers.

List of Simple Programs (short programs)

1. Converting °C temperature to °F.
2. To carry out arithmetic calculations.
3. To check whether given number is odd or even.
4. To check whether given number m is divisible by n or not.
5. To find maximum of 2 numbers or 3 numbers.
6. To find area of triangle and circle.
7. To find roots of quadratic equation.
8. To check whether integer is prime or not.
9. To find mean, Geometric mean and Harmonic Mean of n numbers.
10. To prepare multiplication table.
11. To find sum of digits of a number.
12. To solve simultaneous linear equations. (two equations in two variables)
13. To evaluate simple and compound interest
14. To evaluate exp(x), sin (x), log (x) etc. using Taylor"s series expansion.
15. To convert decimal number to equivalent binary number.
16. To generate Fibonacci series like 0, 1, 1,2,3,5…
17. To test palindrome string using string function.
18. To sort a string using string function.
19. To search string using string function.
20. To combine given two strings using string function.

List of programs (long programs)

21. Program in C to prepare a frequency distribution with given class interval from raw data.
22. Program in C to find mean, variance, standard deviation and quartiles for given n observations and frequency distribution.
23. Program in C to fit a Binomial distribution to given data.

Books Recommended:

1. How to Solve it by Computer, R.G. Dromey, Pearson Education.
2. Problem Solving and Programming Concept, Maureen Sprankle,7th Edition, Pearson Publication.
3. C: the Complete Reference, Schildt Herbert, 4 th edition, McGraw Hill
4. A Structured Programming Approach Using C, Behrouz A. Forouzan, Richard F. Gilberg, Cengage Learning India
5. The 'C' programming language, Brian Kernighan, Dennis Ritchie, PHI
6. Programming in C, A Practical Approach, Ajay Mittal, Pearson
7. Programming with C, B. Gottfried, 3rd edition, Schaum's outline Series, Tata McGraw Hill. 8. Programming in ANSI C, E. Balagurusamy, 7th Edition, McGraw Hil.
8. Let us C, Kanitkar, Y (2008) BFB publishers, New Delhi.

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Solving problems using programming capabilities and exploring algorithmic approaches contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Strongly Related (3) - Exploring algorithmic approaches, developing modular programs, and applying critical thinking in problem-solving align with this program outcome.

PO3: Social Competence

CO3: Student will be developed modular programs using control structures, pointers, arrays, strings, and functions

Justification: Partially Related (2) - While the development of modular programs involves collaboration, the direct link to social competence is limited.

PO4: Research-related Skills and Scientific Temper

CO2: Student will be exploring their algorithmic approaches to problem-solving

Justification: Partially Related (2) - Exploring algorithmic approaches contributes to research-related skills and scientific temper, although the direct link is moderate.

PO5: Trans-disciplinary Knowledge

All Course Outcomes are Moderately to Strongly Related (2-3) - The understanding and application of C programming principles contribute to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Strongly Related (3) - Performing independently and collaboratively, executing interpersonal relationships, and committing to professional ethics are inherent in programming tasks.

PO7: Effective Citizenship and Ethics

All Course Outcomes are Moderately to Strongly Related (2-3) - While programming tasks themselves may not directly address citizenship, understanding ethical coding practices is relevant.

PO8: Environment and Sustainability

CO1: Student will be solved to problems using programming capability

Justification: Partially Related (1) - Direct application to environmental and sustainability aspects is limited.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Strongly Related (3) - Acquiring the ability to engage in independent and life-long learning is intrinsic to programming skills development.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code : USST356(A)
Paper : VI (A) Title of Paper : Introduction to Stochastic Processes
Credit : 3 credits No. of lectures : 48

A) Learning objectives:

1. Define stochastic processes and their importance in modeling random phenomena over time.
2. Introduce different types of stochastic processes including discrete-time and continuous-time processes.
3. To provide the students with a fundamental understanding of the stochastic processes and Markov chains.
4. Students should be able to construct transition probability matrix (tpm), find the n-step transition probabilities and classify its states.
5. Define the Markov property and explain its significance in modeling random systems.
6. Introduce concepts such as transient states, recurrent states, and absorbing states.
7. Understand the properties and characteristics of Poisson processes.

B) Course outcomes:

CO 1. Students will be able to formulate tpm, n-step transition probabilities
CO 2. Students will be able to classify of states.
CO 3. Students will become familiar with Poisson process.
CO 4. This text provides an in-depth understanding of stationary distributions in the context of stochastic processes and their key properties.
CO 5. Explore applications of stationary distributions in various fields, including queueing theory, reliability analysis, and population dynamics.
CO 6. Develop a deep understanding of the definition and fundamental properties of Poisson process.
CO 7. Develop skills in using stochastic processes for modeling and forecasting future events and outcomes.

TOPICS/CONTENTS:

UNIT 1: Introduction (18 L)

Definition of a Stochastic process, state space ,parameter space, types of stochastic processes, Markov Chains (MC) $\{X_n, n \geq 0\}$, finite MC, time homogeneous MC one step transition probabilities, and transition probability matrix (t.p.m.), stochastic matrix, Chapman Kolmogorov equation, n-step transition probability matrix, initial distribution, joint distribution function of $\{X_0, X_1, \ldots, X_n\}$, partial sum of independent and identically distributed random variables as Markov Chain, illustrations such as random walk, Gambler's ruin problem, Ehrenfest chain.

UNIT 2: Classification of States (12 L)

Classification of states: Communicating states, first return probability, probability of ever return Classification of states, as persistent and transient states. Decomposition of state space, closed set of states, irreducible set of states, irreducible MC, periodicity of M.C. aperiodic M.C. ergodic M. C.

UNIT 3: Stationary distribution (6 L)

Stationary distribution for an irreducible ergodic finite Long run behaviour of a MC

UNIT 4: Poisson Process (12L)

Poisson process: Postulates and properties of Poisson process, probability distribution of N(t), the number of occurrences of the event in (0, t], Poisson process and probability distribution of inter-arrival time, mean, variance and covariance functions. Definition of compound Poisson

Books Recommended:

1. Medhi J. (1982) Stochastic processes (Wiley Eastern)
2. Ross, S. (1996) Stochastic processes (John Wiley)
3. Ross, S. (2000) Introduction to probability models, 7th edition (Academic Press)
4. Hoel , P.G.,Port, S.C. ,Stone, C.J. (1972) : Introduction to stochastic processes
5. Bhat, B.R. (2000) stochastic models: Analysis and applications (New Age International)
6. Adke, S.R., Manjunath, S.M. (1984) An introduction to finite Markov processes (Wiley Eastern)
7. Taylor, H N and Karlin, S. (1984) An introduction to stochastic modeling(Academic Press)

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Formulating transition probabilities, understanding Poisson processes, and studying stationary distributions contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Strongly Related (3) - Understanding and classifying states in stochastic processes require critical thinking skills, contributing to problem-solving.

PO3: Social Competence

CO1: Students will be able to formulate TPM, n-step transition probabilities

Justification: Partially Related (2) - While the concept itself may not directly involve social competence, the effective communication of results can contribute to this outcome.

PO4: Research-related Skills and Scientific Temper

CO4: This text provides an in-depth understanding of stationary distributions in the context of stochastic processes and their key properties.

Justification: Strongly Related (3) - Understanding stationary distributions in stochastic processes aligns with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

CO5: Explore applications of stationary distributions in various fields, including queueing theory, reliability analysis, and population dynamics.

Justification: Strongly Related (3) - The exploration of applications in various fields contributes to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Moderately to Strongly Related (2-3) - Skills in using stochastic processes for modeling and forecasting future events contribute to personal and professional competence.

PO7: Effective Citizenship and Ethics

All Course Outcomes are Moderately Related (2-3) - While stochastic processes may not

directly involve citizenship, understanding and applying them ethically contribute to this outcome.

PO8: Environment and Sustainability

CO2: Students will be able to classify states.

Justification: Partially Related (1) - Direct application to environmental and sustainability aspects is limited.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Strongly Related (3) - Acquiring skills in modeling and forecasting using stochastic processes aligns with the ability to engage in independent and life-long learning.

SYLLABUS (CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code	: USST356(B)		
Paper	: VI (B)	Title of Paper	: Biostatistics
Credit	: 3 credits	No. of lectures	: 48

A) Learning objectives:

1. The main objective of this course is to learn and understand a basic concept of emerging branch of clinical trials belongs to biostatistics.
2. Students should be able to understand the principles of epidemiology and discussion of the concept of natural history of disease particularly with respect to possible clinical interventions.
3. Students should be understanding the phases of clinical trials and the types of study designs typically used in clinical trials, use of randomization and blinding.
4. Students should be understanding the purposes for conducting clinical trials.
5. Understand the role of biostatistics in biomedical research and public health.
6. Define epidemiology and understand its significance in public health.
7. Understand the strengths and limitations of various study designs.

B) Course outcomes:

CO 1. Students will be able to understand the basic concept of clinical trials.

CO 2. Students will be able to identify epidemic events in real life situations.

CO 3. Students will be able to understand the designs which typically used in clinical trials.

CO 4. Students will be able to apply appropriate design from clinical trials.

CO 5. Learn to use descriptive statistical methods to summarize and present data in the context of biological and health sciences.

CO 6. Understand the fundamental principles and phases of clinical trials, including their design, conduct, and regulatory aspects.

CO 7. Explore ethical principles and regulatory guidelines governing clinical trials,

TOPICS/CONTENTS:

Unit-1 Epidemiology **(16 L)**

1.1 Introduction to Epidemiology

1.2 Odds, odds ratio, relative risk.

1.3 Estimation of odds ratio (OR), Confidence interval for OR. Relation

1.4 Symmetry in square contingency tables, collapsing tables and Simpson's paradox.

Unit-2 Clinical trials (12 L)

2.1 General information on history of drug discovery including Louis Pasteur (rabies and small pox), Ronald Ross and malaria, Alexander Fleming and penicillin, Jonas Salk and polio, cholera, asthma, diabetes, blood pressure, heart attack, arthritis.

2.2 Phases of clinical trial, purpose, duration, cost, drug regulatory bodies, ICH, statistical analysis plan, clinical study report.

Unit-3 Design of clinical trials (15 L)

3.1 Phases of clinical trial, purpose, duration, cost, drug regulatory bodies, ICH, statistical analysis plan, clinical study report.

3.2 Parallel designs, case control studies, longitudinal studies, safety studies

3.3 Treatments, 2 periods cross over design.

Unit-4 Bioequivalence and bio-availability (5 L)

4.1 Bioequivalence and bio-availability, non-inferiority trial

4.2 Practice based medical research, evidence-based medicine

Books Recommended:

1. A. P. Gore and S. A, Paranjape (2000) Course on mathematical and statistical Ecology (Kluwer publishing Holland)
2. M. B. Kulkarni, V. R. Prayag, (2004) Introduction to Statistical Ecology (SIPF Academy, Nasik)
3. Alan Agrasti (1996) Introduction to Categoric Data Analysis (Wiley) for part–II epidemiology (mainly odds, odds ratios and inference) For the more reference books we need to see the books in the department of Statistics SPPU, Pune.
4. J. N. S. Matthews: Chapman and Hall (2006) Introduction to Randomized Controlled clinical Trials
5. Stephen Sann (2000) Statistical Issues in drug Development (John Wiley)
6. Steven Diantadosi (2000) Clinical Trials – A methodological perpective (John Wiley)
7. L.M. Friedmon, C.D. Forbes, D.L. Demats (TT) Fundamentals of Clinics Trials (Spinner)
8. Steve selvin (2000) Epidemiologic Analysis (Oxford)
9. M.M. Shoukni, C.A. Pavse(1999) Statistical Methods for Health Sciences (CPC Pree)

10. Steve Salvin (1999) Statistical Analysis of Epidomiologic Data (Ph. D: Oxford)

11. A. P. Gore, S. A. Paranjpe and M. B. Kulkarni (2010) Lecture Notes on Medical Statistics

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Understanding clinical trial concepts, epidemic events, and designs contributes to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Moderately to Strongly Related (2-3) - Identifying epidemic events, understanding clinical trial designs, and applying appropriate designs involve critical thinking skills.

PO3: Social Competence

CO1: Students will be able to understand the basic concept of clinical trials.

Justification: Moderately Related (2) - Understanding clinical trials may indirectly involve social competence, especially in communicating results.

PO4: Research-related Skills and Scientific Temper

CO7: Explore ethical principles and regulatory guidelines governing clinical trials.

Justification: Moderately Related (2) - Understanding ethical principles and regulations aligns with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

CO5: Learn to use descriptive statistical methods to summarize and present data in the context of biological and health sciences.

Justification: Moderately Related (2) - Descriptive statistics in the context of health sciences contribute to trans-disciplinary knowledge.

PO6: Personal and Professional Competence

All Course Outcomes are Moderately to Strongly Related (2-3) - Skills in clinical trial design and understanding regulatory aspects contribute to personal and professional competence.

PO7: Effective Citizenship and Ethics

CO7: Explore ethical principles and regulatory guidelines governing clinical trials.

Justification: Strongly Related (3) - Exploring ethical principles and guidelines aligns directly with effective citizenship and ethics.

PO8: Environment and Sustainability

All Course Outcomes are Moderately to Partially Related (1-2) - While clinical trials may not have a direct impact on the environment, understanding ethical and regulatory aspects partially contributes to sustainability.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Moderately to Strongly Related (2-3) - Acquiring skills in clinical trial design and ethical considerations aligns with the ability to engage in independent and life-long learning.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code : USST357
Paper : VII Title of Paper : Statistics Practical- V
Credit : 2 credits

A) Learning objectives:

1. Learn how to design and analyze factorial experiments with two or more factors.
2. Students should be able to identify the design, carryout various experiments and analyze the data.
3. Students should be able to apply appropriate design in real life situation.
4. To learn and understand the various analysis techniques in designs of experiments such as ANOVA, ANOCOVA, etc.
5. Students will be able to apply Factorial design, confounding in real life problems.
6. Students should be able to analyze the data of various experimental designs.
7. Learn about confounding in experimental designs.
8. Students should be able to identify the design, carryout various experiments and analyze the data.

B) Course outcomes:

CO 1. Students will be able to understand basic principles and various terms of Design of Experiments.

CO 2. Students will be able to apply Factorial design, confounding in real life problems.

CO 3. Students should be able to analyze the data of various experimental design.

CO 4. Students should be able to analyze factorial designs, exploring the effects of multiple factors and their interactions on the response variable.

CO 5. Learn to use fractional factorial designs to efficiently study the effects of a subset of factors, reducing the number of experimental runs.

CO 6. Develop skills to interpret and draw meaningful conclusions from experimental results.

CO 7. Apply experimental design principles to real-world problems and scenarios, emphasizing the practical aspects of designing experiments in various fields.

Sr. No.	Title of Experiments
1.	Analysis of CRD (equal and unequal replications, pairwise comparison of treatments, using critical difference (C.D). Check normality using normal probability plot.
2.	Analysis of RBD (pairwise comparison of treatments using i) C.D ii) Tukey test iii) Scheff's test. Efficiency of RBD w.r.t. CRD
3.	Analysis of RBD. Efficiency of RBD w.r.t. CRD
4.	Analysis of LSD and Calculation of Efficiency (pairwise comparison of treatments using C.D. and box plot, efficiency of LSD w.r.t. i) CRD ii) RBD)
5.	Kruskal-Wallies H test
6.	Analysis of Covariance in CRD
7.	Analysis of Covariance in RBD
8.	Analysis of 2^2 and 2^3 factorial experiments in RBD.
9.	Analysis of 2^3 factorial experiments in RBD (partial confounding)
10.	Analysis of 2^3 factorial experiments in RBD (total confounding)

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

PO1: Disciplinary Knowledge

All Course Outcomes are Strongly Related (3) - Understanding principles, terms of Design of Experiments, and analyzing experimental data contribute to comprehensive knowledge in the discipline.

PO2: Critical Thinking and Problem Solving

All Course Outcomes are Moderately to Strongly Related (2-3) - Applying factorial design, analyzing data, and interpreting results involve critical thinking skills.

PO3: Social Competence

CO1: Students will be able to understand basic principles and various terms of Design of Experiments.

Justification: Moderately Related (2) - Understanding experimental design principles may

indirectly involve social competence, especially in communicating results.

PO4: Research-related Skills and Scientific Temper

CO5: Learn to use fractional factorial designs to efficiently study the effects of a subset of factors, reducing the number of experimental runs.

Justification: Moderately Related (2) - Using fractional factorial designs aligns with research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

All Course Outcomes are Moderately to Partially Related (1-2) - While experimental design may not be directly trans-disciplinary, applying principles to real-world problems contributes partially.

PO6: Personal and Professional Competence

All Course Outcomes are Moderately to Strongly Related (2-3) - Skills in experimental design and interpretation contribute to personal and professional competence.

PO7: Effective Citizenship and Ethics

CO7: Apply experimental design principles to real-world problems and scenarios, emphasizing the practical aspects of designing experiments in various fields.

Justification: Moderately Related (2) - Applying principles to real-world problems involves considering ethical aspects.

PO8: Environment and Sustainability

All Course Outcomes are Partially Related (1-2) - Experimental design may not have a direct impact on the environment, but considering practical aspects may contribute partially to sustainability.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Moderately to Strongly Related (2-3) - Acquiring skills in experimental design and analysis aligns with the ability to engage in independent and life-long learning.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code : USST358
Paper : VIII Title of Paper : Statistics Practical- VI
Credit : 2 credits

A) Learning Objectives:

1. Students should be able to understand properties and applications of standard distribution.
2. To get knowledge about important inferential aspects of interval estimation.
3. Estimating population parameters using sampling distribution of estimator.
4. Obtaining estimators of standard error in estimation under various sampling procedures.
5. Determining adequate sample size for various sampling procedures.
6. Understand the method of moments and derive moment estimators for standard distributions.
7. To understand the important of inferential aspects such as point estimation and interval estimation.

B) Course Outcomes:

CO 1. Student will be able to fit the distributions.

CO 2. Students will be able to draw model sample from distributions.

CO 3. Students will be able to apply appropriate sample survey design for related problems.

CO 4. Estimates the convenient sample size for Simple random sampling and stratified random sampling.

CO 5. Apply various sampling techniques, such as simple random sampling, stratified sampling, cluster sampling, and systematic sampling, based on the specific requirements of different research scenarios.

CO 6. Develop a sampling plan for a given research question or problem, considering factors such as population characteristics, sampling frame, and research objectives.

CO 7. Apply various probability distributions to real-world scenarios and problem-solving.

Sr. No.	Title of Experiments
1.	Model sampling from Cauchy and Laplace distributions
2.	Fitting of lognormal distribution
3.	M.L.E and moment estimator of truncated Binomial and truncated Poisson distributions (truncated at zero)
4.	Construction of confidence interval for population median and quartiles, based on order statistics.
5.	Simple random sampling (estimation of population mean, population total with standard errors), i) with replacement, ii) without replacement. Confidence interval for population mean and population total.
6.	Stratified random sampling: Proportional and Neyman allocation, comparison with SRSWOR.
7.	Stratified random sampling: cost and variance analysis.
8.	Ratio methods of estimation. Comparison with SRSWOR.
9.	Regression methods of estimation. Comparison with SRSWOR.
10.	Determination of Sample Size.

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

PO1: Disciplinary Knowledge

CO1: Student will be able to fit the distributions.

Justification: Strongly Related (3) - Fitting distributions is a fundamental aspect of statistical and disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO2: Students will be able to draw model sample from distributions.

Justification: Strongly Related (3) - Drawing samples involves critical thinking and problem-solving skills.

PO3: Social Competence

All Course Outcomes are Partially to Moderately Related (1-2) - Although the primary focus is on statistical skills, some aspects may contribute to social competence, especially in communicating research findings.

PO4: Research-related Skills and Scientific Temper

All Course Outcomes are Partially to Moderately Related (1-2) - Designing sample surveys and estimating sample sizes contribute to research-related skills and scientific temper.

PO5: Trans-disciplinary Knowledge

CO5: Apply various sampling techniques, such as simple random sampling, stratified sampling, cluster sampling, and systematic sampling, based on the specific requirements of different research scenarios.

Justification: Moderately Related (2) - Applying sampling techniques may have relevance in trans-disciplinary scenarios.

PO6: Personal and Professional Competence

All Course Outcomes are Partially to Moderately Related (1-2) - Skills in sampling design and statistical analysis contribute to personal and professional competence.

PO7: Effective Citizenship and Ethics

CO6: Develop a sampling plan for a given research question or problem, considering factors such as population characteristics, sampling frame, and research objectives.

Justification: Moderately Related (2) - Considering factors in a sampling plan involves ethical considerations.

PO8: Environment and Sustainability

All Course Outcomes are Partially to Moderately Related (1-2) - While statistical skills may not directly impact the environment, some considerations in sampling may contribute partially to sustainability.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Moderately Related (2) - Acquiring skills in statistical analysis and sampling aligns with the ability to engage in independent and life-long learning.

SYLLABUS(CBCS) FOR T. Y. B. Sc. (Semester- V) STATISTICS
2022 Pattern
(With Effect from Academic Year 2024-2025)

Paper Code : USST359
Paper : IX Title of Paper : Statistics Practical- VII
Credit : 2 credits

A) Learning objectives:

Students successfully completing this course will be able:

1. The objective of the course is to develop problem solving abilities using computers.
2. The student will develop skills for writing programs using C.
3. Understand the fundamentals of the C programming language.
4. Learn the basic syntax and structure of C programs.
5. Understand concepts such as variables, data types, and operators.
6. Learn how to declare, initialize, and access elements of arrays and pointers.
7. The course realizes and design algorithm for problem solving.
8. The objective of the course is to develop problem solving abilities using computers.

B) Course Outcomes:

CO 1. Student will be solved to problems using programming capability.

CO 2. Student will be exploring their algorithmic approaches to problem solving.

CO 3. Student will be developed modular programs using control structures, pointers, arrays, strings and functions.

CO 4. Acquire skills in debugging C programs, identifying and fixing common errors, and using debugging tools effectively.

CO 5. Apply arrays and strings in C to store and manipulate collections of data, demonstrating an understanding of array indexing and string manipulation functions.

CO 6. Demonstrate a solid understanding of the basic syntax, structure, and concepts of the C programming language.

CO 7. Demonstrate knowledge of different data types in C, their usage, and the concept of variables in programming.

Sr. No.	Title of Experiments
1.	A) Converting °C temperature to °F. B) To check whether given number is odd or even. C) To find maximum of 2 numbers or 3 numbers. D) To find area of triangle and circle.
2.	A) To find roots of quadratic equation.
3.	To check whether integer is prime or not.
4.	To find mean, Geometric mean and Harmonic Mean of n numbers.
5.	A) To find mean, variance and coefficient of variation of n observations. B) Arrange the observations in ascending order of magnitude and find median of n observations.
6.	To find mean, median, variance and coefficient of variation of frequency distribution when fi and xi are given.
7.	To find correlation coefficient for a given bivariate data.
8.	To fit a line of regression of Y on X for a given bivariate data.
9.	To fit a Binomial distribution to given data.
10.	To obtain addition of two matrices, multiplication of two matrices.

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

PO1: Disciplinary Knowledge

CO6: Demonstrate a solid understanding of the basic syntax, structure, and concepts of the C programming language.

Justification: Moderately Related (2) - Understanding the basics of a programming language contributes to disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

CO2: Student will be exploring their algorithmic approaches to problem solving.

Justification: Strongly Related (3) - Exploring algorithmic approaches requires critical thinking and problem-solving skills.

PO3: Social Competence

All Course Outcomes are Partially to Moderately Related (1-2) - Programming skills may indirectly contribute to social competence by enabling effective communication.

PO4: Research-related Skills and Scientific Temper

CO4: Acquire skills in debugging C programs, identifying and fixing common errors, and using debugging tools effectively.

Justification: Moderately Related (2) - Debugging skills contribute to research-related skills.

PO5: Trans-disciplinary Knowledge

All Course Outcomes are Partially to Moderately Related (1-2) - While programming skills may have trans-disciplinary applications, the direct impact is limited.

PO6: Personal and Professional Competence

CO3: Student will be developed modular programs using control structures, pointers, arrays, strings and functions.

Justification: Moderately Related (2) - Developing modular programs contributes to personal and professional competence.

PO7: Effective Citizenship and Ethics

CO7: Demonstrate knowledge of different data types in C, their usage, and the concept of variables in programming.

Justification: Moderately Related (2) - Understanding data types and variables includes considerations for effective and ethical programming.

PO8: Environment and Sustainability

All Course Outcomes are Partially to Moderately Related (1-2) - Programming skills may have indirect applications in environmental and sustainability contexts.

PO9: Self-directed and Life-long Learning

All Course Outcomes are Moderately Related (2) - Acquiring programming skills aligns with the ability to engage in independent and life-long learning.