Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Autonomous

Course Structure for S. Y. B. Sc. STATISTICS (2022 Pattern)

(With effect from Academic Year 2023-2024)

Name of the Programme : B.Sc. Statistics

Program Code : USST

Class : S.Y.B.Sc.

Semester : III

Semester	Paper Code	Title of Paper	No. of Credits
III	USST231	Statistical Techniques- I	3
	USST232	Continuous Probability Distributions-I	3
	USST233	Practical Paper –III	2
IV	USST241	Statistical Techniques- II	3
	USST242	Continuous Probability Distributions-II	3
	USST243	Practical Paper-IV	2

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

(2022 Pattern)

(w. e. from June, 2023)

Name of the Programme **:** B.Sc. Statistics

Program Code **:** USST

Class **:** S.Y.B.Sc.

Semester **:** III

Course Name **:** Statistical Techniques – I

Course Code **:** USST231

No. of Lectures **:** 48

No of Credits **:** 3

A) Course Objectives:

1. The main objective of this course is to understand concept of some discrete distributions and truncated distribution with real life situations.
2. Know the relations among the different distributions.
3. Study of various index numbers and utilities with real life situations.
4. To fit the appropriate time series model that can be used.

B) Course Outcome:

Students should be able to:

- CO1. Understand discrete distributions with real life situations.
- CO2. Learn Negative and multinomial distributions.
- CO3. Learn truncated distributions
- CO4. Learn the concept of index numbers and time series.
- CO5. Explore various time series forecasting techniques, such as autoregressive integrated moving average (ARIMA) models and exponential smoothing.
- CO6. Apply time series analysis in practical business and economic scenarios.
- CO7. Understand how time series data is used for decision-making and planning.

TOPICS/CONTENTS:

Unit 1: Standard Discrete Distributions: (22 L)

1.1 Negative Binomial Distribution:

Probability mass function (p.m.f.)

$$P(X = x) = \binom{x+k-1}{x} p^k q^x \quad ; x = 0, 1, 2, \dots$$

$$; 0 < p < 1 ; q = 1 - p; k > 0$$

$$= 0 \quad ; \quad otherwise.$$

Notation: $X \sim NB(k,p)$.

Nature of probability curve, negative binomial distribution as a waiting time distribution, moment generating function (MGF), cumulant generating function (CGF), mean, variance, skewness, kurtosis (recurrence relation between moments is not expected), additive property of NB(k,p). Relation between geometric distribution and negative binomial distribution. Poisson approximation to negative binomial distribution. Real life situations.

1.2 Multinomial Distribution: Probability mass function (p.m.f.)

$$P(X_1 = x_1, X_2 = x_2, \dots, X_k = x_k) = \frac{n!\, {p_1}^{x_1} {p_2}^{x_2} \dots . {p_k}^{x_k}}{x_1!\, x_2! \dots . x_k!} ; x_i = 0, 1, 2, \dots, n - \sum_{1}^{i-1} x_r$$

$$; i = 1, 2, \dots, k$$

$$; x_1 + x_2 + \dots + x_k = n$$

$$; 0 < p_i < 1; i = 1, 2, \dots, k$$

$$; p_1 + p_2 + \dots + p_k = 1$$

$$= 0 \quad ; otherwise$$

$Notation$: $(X_1, X_2, \dots, X_k) \sim MD(n, p_1, p_2, \dots, p_k)$, $\underline{X} \sim MD(n, \underline{p})$,

$where\ \underline{X} = (X_1, X_2, \dots, X_k)$, $\underline{p} = (p_1, p_2, \dots, p_k)$.

Joint MGF of $(X_1, X_2, \dots, X_k)$, use of MGF to obtain means, variances, covariances, total correlation coefficients, variance – covariance matrix, rank of variance – covariance matrix and its interpretation, additive property of multinomial distribution, univariate marginal distribution, distribution of $Xi + Xj$, conditional distribution of Xi given $Xj = r$, conditional distribution of Xi given $Xi + Xj = r$, real life situations and applications.

1.3 Truncated Distributions:

Concept of truncated distribution, truncation to the right, left and on both sides. Binomial distribution left truncated at $X = 0$ (value zero is discarded), its p.m.f., mean & variance. Poisson distribution left truncated at $X = 0$ (value zero is discarded), its p.m.f., mean & variance. Real life situations and applications.

Unit 2: Index Numbers: (09L)

2.1 Introduction.

2.2 Definition and Meaning.

2.3 Problems/considerations in the construction of index numbers.

2.4 Simple and weighted price index numbers based on price relatives. **(For practical only)**

2.5 Simple and weighted price index numbers based on aggregates. **(For practical only)**

2.6 Laspeyre's, Paasche's and Fisher's Index numbers.

2.7 Test of adequacy for an Index Number (i) Time Reversal Test (ii) Factor Reversal Test

2.8 Consumer price index number: Considerations in its construction. Methods of construction of consumer price index number - (i) family budget method (ii) aggregate expenditure method.

2.9 Base Shifting, splicing, deflating, and purchasing power. **(For practical only)**

2.10 Description of the BSE sensitivity and similar index numbers.

Unit 3: Time Series: (12L)

3.1 Meaning and utility of time series, components of time series: trend, seasonal variations, cyclical variations, irregular (error) fluctuations.

3.2 Exploratory data analysis: Time series plot to (i) check any trend & seasonality in the time series (ii) capture trend.

3.3 Methods of trend estimation and smoothing: (i) moving average, (ii) curve fitting by least square principle, (iii) exponential smoothing.

3.4 Choosing parameters for smoothing and forecasting.

3.5 Forecasting based on exponential smoothing.

3.6 Measurement of seasonal variations: i) simple average method, ii) ratio to moving average method, iii) ratio to trend where trend is calculated by method of least squares. **(For practical only)**

3.7 Fitting of autoregressive model $AR\ (p)$, where $p\ =\ 1,2$.

3.8 Case studies of real life Time Series: Price index series, share price index series, economic time series: temperature and rainfall time series, wind speed time series, pollution levels.

Unit 4: Chebychev's Inequality: (5L)

4.1 For discrete and continuous distribution.

4.2 Examples and problems on Binomial, Normal and Exponential distributions.

Reference Books:

1. Brockwell P. J. and Davis R. A. (2003), Introduction to Time Series and Forecasting (Second Edition), Springer Texts in Statistics
2. Chatfield C. (2001), The Analysis of Time Series An Introduction, Chapman and Hall / CRC, Texts in Statistical Science .
3. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), Fundamentals of Statistics, Vol. 2, World Press, Kolkata.
4. Gupta, S. C. and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, (Eleventh Edition), Sultan Chand and Sons, 23, Daryaganj, New Delhi , 110002 .
5. Gupta, S. C. and Kapoor V. K. (2007), Fundamentals of Applied Statistics (Fourth Edition), Sultan Chand and Sons, New Delhi.
6. Gupta, S. P. (2002), Statistical Methods (Thirty First Edition), Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
7. Mukhopadhya Parimal (1999), Applied Statistics, New Central Book Agency, Pvt. Ltd. Kolkata

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

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

PO1: Disciplinary Knowledge

CO1: Understand discrete distributions with real-life situations.

- Weight: 3 (Strongly Related)
- Justification: Disciplinary knowledge in probability and statistics is crucial for understanding and interpreting discrete distributions, which are foundational in these fields. The ability to apply these concepts to real-life situations enhances disciplinary knowledge.

CO2: Learn Negative and multinomial distributions.

- Weight: 3 (Strongly Related)
- Justification: Negative and multinomial distributions are specific types of discrete distributions. Understanding these distributions contributes directly to the disciplinary knowledge in probability and statistics.

CO3: Learn truncated distributions.

- Weight: 3 (Strongly Related)
- Justification: Truncated distributions are a specialized aspect of probability theory. Knowledge of these distributions adds depth to the understanding of discrete distributions, aligning with the disciplinary knowledge in probability and statistics.

CO4: Learn the concept of index numbers and time series.

- Weight: 2 (Moderately Related)
- Justification: While index numbers and time series are relevant to statistical analysis, they are not directly tied to discrete distributions. However, they form a bridge to time series analysis, contributing moderately to disciplinary knowledge.

CO5: Explore various time series forecasting techniques, such as autoregressive integrated moving average (ARIMA) models and exponential smoothing.

- Weight: 2 (Moderately Related)
- Justification: Time series forecasting techniques introduce forecasting methods that are beyond the scope of discrete distributions. However, it enhances the understanding of data analysis and forecasting within the broader discipline of statistics.

CO6: Apply time series analysis in practical business and economic scenarios.

- Weight: 2 (Moderately Related)
- Justification: Application of time series analysis, while valuable, involves broader statistical concepts beyond discrete distributions. It contributes moderately to disciplinary knowledge by applying statistical techniques to real-world scenarios.

CO7: Understand how time series data is used for decision-making and planning.

- Weight: 2 (Moderately Related)

- Justification: Decision-making and planning based on time series data involve broader considerations than discrete distributions alone. This contributes moderately to disciplinary knowledge by emphasizing the application of statistical methods in decision-making.

PO2: Critical Thinking and Problem Solving
- All COs contribute to critical thinking and problem-solving by fostering analytical skills, allowing students to apply statistical concepts to solve problems.

PO4: Research-Related Skills
- COs 1, 2, and 3 contribute to research-related skills by providing a foundational understanding of probability and statistics.

PO5: Personal and Professional Competence
- All COs, especially those related to time series analysis, contribute to the development of personal and professional competence by providing practical skills in statistical analysis.

PO8: Self-directed and Life-long Learning
- All COs contribute to self-directed learning by providing foundational knowledge and skills in probability and statistics.

SYLLABUS (CBCS) FOR S. Y. B. Sc. STATISTICS

(2022 Pattern)
(w. e. from June, 2023)

Name of the Programme **:** B.Sc. Statistics

Program Code **:** USST

Class	**:** S.Y.B.Sc.
Semester	**:** III
Course Name	**:** CONTINUOUS PROBABILITY DISTRIBUTIONS – I
Course Code	**:** USST232
No. of lectures	**:** 48
No. of Credits	**:** 3

A) Course Objectives:

1. The main objective of this course is to understand concept of continuous distributions with real life situations.
2. To identify the appropriate probability model that can be used.
3. Find various measures of r.v. and probabilities using its probability distributions.
4. Know the relations among the different distributions.
5. Understand the concept of transformation of univariate and bivariate continuous random variables.

B) Course Outcome:

Students should be able to:

CO1. Define and understand the concept of continuous random variables.
CO2. Understand continuous distributions with real life situations.
CO3. Understand the statement and significance of the central limit theorem for continuous random variables.
CO4. Learn uniform, Normal, exponential and Gamma distributions.
CO5. Learn Bivariate distributions
CO6. Learn the relations among the different distributions
CO7. Learn the concept of transformation of continuous random variables which help to study derived distributions.

TOPICS/CONTENTS:

UNIT 1: Functions and Properties of functions **(04 L)**

Definition of function, Continuous function, Monotonic function, One to one function, Onto function, Inverse function.

UNIT 2: Continuous Univariate Distributions **(10 L)**

2.1 Continuous sample space: Definition, illustrations.

Continuous random variable: Definition, probability density function (p.d.f.), cumulative distribution function (c.d.f.), properties of c.d.f. (without proof), probabilities of events related to random variable.

2.2 Expectation of continuous r.v., expectation of function of r.v. E[g(X)], mean, variance, geometric mean, harmonic mean, raw and central moments, skewness, kurtosis.

2.3 Moment generating function (M.G.F.): Definition and properties, cumulant generating function (C. G. F.): definition**,** properties.

2.4 Mode, median, quartiles.

2.5 Probability distribution of function of r. v. : Y = g(X) using

i) Jacobian of transformation for g(.) monotonic function and one-to-one, on to functions,

ii) Distribution function for $Y = X^2$, Y = |X| etc.,

iii) M.G.F. of g(X).

UNIT 3: Continuous Bivariate Distributions: (12 L)

3.1 Continuous bivariate random vector or variable (X, Y): Joint p. d. f. , joint c. d. f , properties (without proof), probabilities of events related to r.v. (events in terms of regions bounded by regular curves, circles, straight lines). Marginal and conditional distributions

3.2 Expectation of r.v., expectation of function of r.v. E[g(X, Y)], joint moments, Cov (X,Y), Corr (X, Y), conditional mean, conditional variance, E[E(X|Y = y)] = E(X), regression as a conditional expectation.

3.3 Independence of r. v. (X, Y) and its extension to k dimensional r. v. Theorems on expectation: i) E(X + Y) = E(X) + E(Y), (ii) E(XY) = E(X) E(Y), if X and Y are independent, generalization to k variables. E(aX + bY + c), Var (aX + bY + c).

3.4 M.G.F. : $M_{X,Y}(t_1, t_2)$, properties, M.G.F. of marginal distribution of r. v.s., properties,

i) $M_{X,Y}(t_1, t_2) = M_X(t_1,0)\, M_Y(0,t_2)$, if X and Y are independent r. v.s.

ii) $M_{X+Y}(t) = M_{X,Y}(t, t)$.

iii) $M_{X+Y}(t) = M_X(t)\, M_Y(t)$ if X and Y are independent r.v.s.

3.5 Probability distribution of transformation of bivariate r. v. $U = \phi_1(X, Y)$, $V = \phi_2(X, Y)$

UNIT 4: Standard Univariate Continuous Distributions: (22 L)

4.1 Uniform or Rectangular Distribution:

Probability density function (p.d.f.) $f(x) = \begin{cases} \frac{1}{b-a} & ;\ a \le x \le b \\ 0 & ;\ \text{Otherwise} \end{cases}$

Notation : X ~ U[a, b], sketch of p. d. f., c. d. f., mean, variance, symmetry.

Distribution of i) $\frac{X-a}{b-a}$ ii) $\frac{b-X}{b-a}$ iii) Y=F(X), where F(X) is the c.d.f. of continuous r.v.

X.

Application of the result to model sampling. (Distributions of X + Y, X – Y, XY and X/Y are not expected.)

4.2 Normal Distribution:

Probability density function (p. d. f.)

$$f(x) = \begin{cases} \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{1}{-2\sigma^2}(x-\mu)^2} & ; -\infty < x < \infty; -\infty < \mu < \infty; \sigma > 0 \\ 0 & ; \quad otherwise \end{cases}$$

p. d. f. curve, identification of scale and location parameters, nature of probability curve, mean, variance, M.G.F., C.G.F., central moments, cumulants, β_1, β_2, γ_1, γ_2, median, mode, quartiles, mean deviation, additive property, computations of normal probabilities using normal probability integral tables, probability distribution of : i) $\frac{X-\mu}{\sigma}$ standard normal variable (S.N.V.), ii) aX + b, iii) aX + bY + c, iv) X^2, where X and Y are independent normal variates. Probability distribution of $\overline{X}$, the mean of n i.i.d. $N(\mu, \sigma^2)$ r.v.s. Statement and proof of central limit theorem (CLT) for i. i. d. r. v. s with finite positive variance. (Proof should be using M.G.F.) Its illustration for Poisson and Binomial distributions.

4.3 Exponential Distribution

Probability density function (p. d. f.) $f(x) = \begin{cases} \alpha e^{-\alpha x}; x \geq 0; \alpha > 0 \\ 0 \quad ; \quad otherwise \end{cases}$

Notation : X ~ Exp(α) .

Nature of p. d. f., density curve, interpretation of α as rate and 1/α as mean, variance, M.G.F., C.G.F., c.d.f., graph of c.d.f., lack of memory property, median, quartiles. Distribution of min(X, Y) with X, Y i. i. d. exponential r. v. s.

4.4 Gamma Distribution:

Probability density function (p. d. f.) $f(x) = \begin{cases} \frac{\alpha^\lambda}{\Gamma\lambda} x^{\lambda-1} e^{-\alpha x}; x \geq 0; \alpha > 0, \lambda > 0 \\ 0 \quad ; \quad otherwise \end{cases}$

Notation : $X \sim G(\alpha , \lambda)$. Nature of probability curve, special cases: i) α=1 , ii) λ= 1, M.G.F., C.G.F., moments, cumulants, β_1, β_2, γ_1, γ_2, mode, additive property. Distribution of sum of n i.i.d. Gamma variates.

Reference Books:

1. Mukhopadhya Parimal (1999), Applied Statistics, New Central Book Agency, Pvt. Ltd. Kolkata
2. Hogg, R. V. and Craig, A. T. , Mckean J. W. (2012), Introduction to Mathematical Statistics (Tenth Impression), Pearson Prentice Hall.
3. Gupta S. C. &Kapoor V.K.: (2002), Fundamentals of Mathematical Statistics. Sultan Chand & sons, New Delhi.
4. Gupta S. C. &Kapoor V.K.: Applied Statistics. Sultan Chand & sons, New Delhi.
5. Walpole R.E. & Mayer R.H.: Probability & Statistics. (Chapter 4, 5, 6, 8, 10) MacMillan Publishing Co. Inc, New York
6. Goon, A.M., Gupta M.K. and Dasgupta B: (1986), Fundamentals of Statistics Vol. I and Vol. II World Press, Calcutta.
7. Meyer, P. L., Introductory Probability and Statistical Applications, Oxford and IBH Publishing Co. New Delhi.
8. Mood, A. M., Graybill F. A. and Bose, F. A. (1974), Introduction to Theory of Statistics (Third Edition, Chapters II, IV, V, VI), McGraw - Hill Series G A 276
9. Ross, S. (2003), A first course in probability (Sixth Edition), Pearson Education publishers, Delhi, India.

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

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

PO1: Disciplinary Knowledge

CO1: Define and understand the concept of continuous random variables.

- Mapping: 3 (Strongly related)

- Justification: This directly contributes to the foundational knowledge in probability and statistics, providing the basis for understanding continuous random variables.

CO2: Understand continuous distributions with real-life situations.

- Mapping: 3 (Strongly related)
- Justification: This directly applies the concept of continuous random variables to real-world scenarios, enhancing disciplinary knowledge.

CO3: Understand the statement and significance of the central limit theorem for continuous random variables.

- Mapping: 3 (Strongly related)
- Justification: The Central Limit Theorem is a crucial aspect of continuous random variables, linking theoretical knowledge to practical applications in statistical inference.

CO4: Learn uniform, Normal, exponential and Gamma distributions.

- Mapping: 3 (Strongly related)
- Justification: This is essential for disciplinary knowledge as it delves into specific continuous probability distributions commonly used in various fields.

CO5: Learn Bivariate distributions.

- Mapping: 2 (Moderately related)
- Justification: Bivariate distributions are related but might not be as fundamental as the univariate distributions in certain contexts. However, they contribute to a more comprehensive understanding.

CO6: Learn the relations among the different distributions.

- Mapping: 3 (Strongly related)
- Justification: Understanding the relationships among different distributions is critical for a deeper grasp of the subject and its applications.

CO7: Learn the concept of transformation of continuous random variables which help to study derived distributions.

- Mapping: 3 (Strongly related)
- Justification: Transformation of random variables is crucial for understanding how different distributions are related, contributing significantly to disciplinary knowledge.

PO2: Critical Thinking and Problem Solving

- All COs contribute significantly to critical thinking and problem-solving skills by providing the necessary tools and concepts to analyze and solve problems related to continuous random variables.
  - Mapping: 3 (Strongly related)
  - Justification: Each CO involves critical thinking processes, such as understanding, analyzing, and applying concepts to solve problems in the context of continuous random variables.

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

- **CO2: Understand continuous distributions with real-life situations.**
  - Mapping: 2 (Moderately related)

        - Justification: Effectively communicating the understanding of continuous distributions can contribute to social competence, especially when explaining complex statistical concepts to non-experts.

PO4: Research-Related Skills

- **CO3: Understand the statement and significance of the central limit theorem for continuous random variables.**
    - Mapping: 3 (Strongly related)
    - Justification: This CO contributes to research-related skills by emphasizing the importance of the central limit theorem in statistical research and experimentation.

PO5: Personal and Professional Competence

- All COs contribute to personal and professional competence by providing a strong foundation in statistical concepts 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

- No direct mapping observed. However, ethical considerations in handling and interpreting data could be implicitly addressed in the context of statistical analysis.
    - Mapping: 1 (Partially related)

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 continuous random variables and distributions, 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

- **CO5: Learn Bivariate distributions.**
    - Mapping: 2 (Moderately related)
    - Justification: Bivariate distributions could be relevant in trans-disciplinary research contexts where understanding the joint behavior of two variables is necessary.

SYLLABUS (CBCS) FOR S. Y. B. Sc. STATISTICS

(2022 Pattern)

(w. e. from June, 2023)

Name of the Programme **:** B.Sc. Statistics

Program Code : USST
Class : S.Y.B.Sc.
Semester : III
Course Name : Practical Paper – III
Course Code : USST233
No. of lectures : 48
No. of Credits : 2

A) Course Objectives:

1. To fit various discrete and continuous distributions, to draw model samples.
2. To study distributions and their applications.

B) Course Outcomes:

CO1. Able to apply negative binomial and multinomial distribution to real life situations
CO2. Able to apply Normal and exponential to real life situations
CO3. Able to fit various distributions to real world scenario.
CO4. Explore various time series forecasting techniques, such as autoregressive integrated moving average (ARIMA) models and exponential smoothing.
CO5. Apply time series analysis in practical business and economic scenarios.
CO6. Understand how time series data is used for decision-making and planning.
CO7. Learn the concept of index numbers and time series.

Sr. No.	Title of the experiment
1.	Fitting of Negative Binomial Distribution, plot of observed and expected frequencies
2.	Fitting of Normal and Exponential Distributions, plot of observed and expected frequencies

3.	Applications of Negative Binomial and Multinomial Distributions
4.	Applications of Normal and Exponential Distributions
5.	Model sampling from i) Exponential distribution using distribution function, ii) Normal distribution using Box-Muller transformation
7.	Fitting of Negative Binomial, Normal and Exponential Distributions using R software
8.	Index Numbers
9.	Time series: Estimation and forecasting of trend by fitting of AR (1) model, exponential smoothing, moving averages.
10.	Estimation of seasonal indices by ratio to trend

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

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

PO1: Disciplinary Knowledge

CO1: Able to apply negative binomial and multinomial distribution to real-life situations.
Mapping: 3 (Strongly related)
Justification: This directly contributes to disciplinary knowledge by applying advanced probability distributions in real-world scenarios.

CO2: Able to apply Normal and exponential to real-life situations.
Mapping: 3 (Strongly related)
Justification: Applying commonly used distributions like Normal and exponential in real-life situations enhances the understanding of fundamental concepts in probability and statistics.

CO3: Able to fit various distributions to real-world scenarios.
Mapping: 3 (Strongly related)
Justification: Understanding how to fit various distributions to real-world data is a crucial aspect of disciplinary knowledge in statistics and probability.

CO4: Explore various time series forecasting techniques, such as autoregressive integrated moving average (ARIMA) models and exponential smoothing.
Mapping: 3 (Strongly related)
Justification: Time series forecasting techniques are a specialized application of statistical methods, contributing significantly to disciplinary knowledge.

CO5: Apply time series analysis in practical business and economic scenarios.
Mapping: 3 (Strongly related)
Justification: Applying time series analysis to business and economic scenarios directly contributes to disciplinary knowledge in the field of statistics and forecasting.

CO6: Understand how time series data is used for decision-making and planning.
Mapping: 3 (Strongly related)
Justification: Understanding the application of time series data in decision-making and planning is a crucial aspect of disciplinary knowledge.

CO7: Learn the concept of index numbers and time series.
Mapping: 3 (Strongly related)
Justification: Learning about index numbers and time series contributes directly to disciplinary knowledge, especially in the context of economic and business data.

PO2: Critical Thinking and Problem Solving
All COs contribute significantly to critical thinking and problem-solving skills by providing the necessary tools and concepts to analyze and solve problems related to advanced probability distributions, time series analysis, and forecasting.
Mapping: 3 (Strongly related)
Justification: Each CO involves critical thinking processes, such as understanding, analyzing, and applying concepts to solve problems in the context of complex 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 concepts to real-life situations and communicate findings is crucial for effective social competence.
PO4: Research-Related Skills

CO4: Explore various time series forecasting techniques, such as autoregressive integrated moving average (ARIMA) models and exponential smoothing.
Mapping: 3 (Strongly related)
Justification: This CO directly contributes to research-related skills by exploring and applying advanced time series forecasting techniques.

PO5: Personal and Professional Competence
All COs contribute to personal and professional competence by providing a strong foundation in statistical concepts 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

No direct mapping observed. However, ethical considerations in handling and interpreting data could be implicitly addressed in the context of statistical analysis.

Mapping: 1 (Partially related)

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

CO5: Apply time series analysis in practical business and economic scenarios.

Mapping: 2 (Moderately related)

Justification: Time series analysis applied in business and economic scenarios may require collaboration with experts from different disciplines, contributing to trans-disciplinary research competence.