Anekant Education Society's

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

(Empowered Autonomous)

Four Year B.Sc. Degree Program in Statistics

(Faculty of Science & Technology)

CBCS Syllabus

T.Y.B.Sc. (Statistics) Semester -VI

Department of Statistics

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus (2023 Pattern)

(As Per NEP 2020)

To be implemented from Academic Year 2025-2026

Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science and Commerce Baramati, Dist-Pune, MS, India.

(Empowered Autonomous)

Board of Studies in Statistics

(Academic Year 2025-26 to 2027-28)

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20.	**Prof. Gardi Chandrakant Gopal**	Subject Expert from Outside the Parent University
21.	**Mr. Kadam Saurabh**	Representative from industry/corporate sector/allied areas
22.	**Dr. Limbore Jaya Laxman**	Member of the College Alumni
23.	**Miss. Shirke Satakshi Shrikant**	UG Student
24.	**Miss. Pathak Siddhi Rajendra**	PG Student

Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science & Commerce, Baramati.

Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati is an empowered autonomous & dynamic institute and has successfully implemented the National Education Policy 2.0 2024 pattern since the academic year 2024-25. We are updating our academic policies as per local needs keeping in view the global perspectives. Accordingly, we have updated our program outcomes as per the graduate attributes defined in New Education Policy. In general, program outcomes are categorized into two categories as disciplinary & interdisciplinary outcomes and generic outcomes.

Program Outcomes for B.Sc.

PO.1. **Comprehensive Knowledge and Understanding**: Graduates will possess a profound understanding of their field of study, including foundational theories, principles, methodologies, and key concepts, within a broader multidisciplinary context.

PO.2. **Practical, Professional, and Procedural Knowledge**: Graduates will acquire practical skills and expertise essential for professional tasks within their field. This includes knowledge of industry standards, best practices, regulations, and ethical considerations, with the ability to apply this knowledge effectively in real-world scenarios.

PO.3. **Entrepreneurial Mindset and Knowledge**: Graduates will cultivate an entrepreneurial mindset, identifying opportunities, fostering innovation, and understanding business principles, market dynamics, and risk management strategies.

PO.4. **Specialized Skills and Competencies**: Graduates will demonstrate proficiency in technical skills, analytical abilities, problem-solving, effective communication, and leadership, relevant to their field of study. They will also adapt and innovate in response to changing circumstances.

PO.5. **Capacity for Application, Problem-Solving, and Analytical Reasoning**: Graduates will possess the capacity to apply learned

concepts in practical settings, solve complex problems, and analyze data effectively. This requires critical thinking, creativity, adaptability, and a readiness to learn and take calculated risks.

PO.6. **Communication Skills and Collaboration**: Graduates will effectively communicate complex information, both orally and in writing, using appropriate media and language. They will also collaborate effectively in diverse teams, demonstrating leadership qualities and facilitating cooperative efforts toward common goals.

PO.7. **Research-related Skills**: Graduates will demonstrate observational and inquiry skills, formulate research questions, and utilize appropriate methodologies for data collection and analysis. They will also adhere to research ethics and effectively report research findings.

PO.8. **Learning How to Learn Skills**: Graduates will acquire new knowledge and skills through self-directed learning, adapt to changing demands, and set and achieve goals independently.

PO.9. **Digital and Technological Skills**: Graduates will demonstrate proficiency in using ICT, accessing information sources, and analyzing data using appropriate software.

PO.10. **Multicultural Competence, Inclusive Spirit, and Empathy**: Graduates will engage effectively in multicultural settings, respecting diverse perspectives, leading diverse teams, and demonstrating empathy and understanding of others' perspectives and emotions.

PO.11. **Value Inculcation and Environmental Awareness**: Graduates will embrace ethical and moral values, practice responsible citizenship, recognize and address ethical issues, and take appropriate actions to promote sustainability and environmental conservation.

PO.12. **Autonomy, Responsibility, and Accountability**: Graduates will apply knowledge and skills independently, manage projects effectively, and demonstrate responsibility and accountability in work and learning contexts.

PO.13. **Community Engagement and Service**: Graduates will actively participate in community-engaged services and activities, promoting societal well-being.

Credit Distribution Structure for F.Y.B.Sc.-2023-2024 (Statistics)

Level	Semester	Major		Minor	GE/OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC, RP	Cum. Cr./ Sem.	Degree/ Cum. Cr.
		Mandatory	Electives							
4.5	I	STA-101-MJM: Descriptive Statistics – I STA-102-MJM: Discrete Probability and Probability Distributions – I STA-103-MJM: Statistics Practical – I Credits-2+2+2	--	--	STA-116-OE: Commercial Statistics STA-117-OE: Introduction to MS-Excel and Statistical Computing Credit- 2+2	STA-121-VSC: Introduction to R Programming Language STA-126-SEC: Statistical Computing Using MS-Excel Credit- 2+2	ENG-131-AEC: Functional English-I STA-137-IKS: Evaluation of Science and Statistics in India EVS-135-VEC: Environmental Science Credit- 2+2+2	CC1: To be selected from the Basket Credit- 2	22	UG Certificate 44
	II	STA-151-MJM: Descriptive Statistics – II STA-152-MJM: Discrete Probability and Probability Distributions – II STA -153-MJM: Statistics Practical – II Credits-2+2+2	--	STA-161-MN: Basic Statistics Credits-2	STA-166-OE: Business Statistics STA-167-OE: Statistics Learning with Software Credit- 2+2	STA-171-VSC: - Data Analysis with R Software STA-176-SEC: Application of Statistics Using Advanced Excel Credit- 2+2	ENG-181-AEC: Functional English-II COS-185-VEC: Digital and Technological Solutions Credit- 2+2	**CC2:** To be selected from the Basket Credit- 2	22	
	Cum Cr.	12	--	2	8	8	10	4	44	

Credit Distribution Structure for S.Y.B.Sc.-2024-2025 (Statistics)

Level	Semester	Major		Minor	GE/OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC, RP	Cum. Cr./ Sem.	Degree/ Cum. Cr.
		Mandatory	Electives							
5.0	III	STA-201-MJM: Continuous Probability Distributions – I (T) STA-202-MJM: Statistical Techniques- I(T) STA-203-MJM: Applied Statistics-I(T) STA-204-MJM Statistics Practical-III (P) **Credits-2+2+2+2**	--	STA-211-MN: Foundations of Probability: Theory and Applications (T) STA-212-MN: Minor Statistics Practical – I (P) **Credit-2+2**	STA-216-OE: Applied Statistical Techniques (T) **Credit- 2**	STA-221-VSC: Quantitative Techniques (T) **Credit- 2**	MAR-231-AEC: भाषिक उपयोजन व लेखन कौशल्ये (T) **Or** HIN-231-AEC: हिंदी भाषा : सृजन कौशल (T) **Or** SAN-231-AEC: प्राथमिक संभाषणकौशल्यम् (T) GEN-245-IKS: Indian Knowledge System (Generic) (T) **Credit- 2+2**	STA-235-FP: Project YOG/PES/CUL/NSS/NCC-239-CC: (T) To be selected from the Basket **Credit- 2+2**	--	**UG Diploma 46**
	IV	STA-251-MJM Continuous Probability Distributions – II (T) STA-252-MJM Statistical Techniques- II (T) STA-253-MJM Applied Statistics-II (T) STA -254-MJM: Statistics Practical – IV(P) **Credits-2+2+2+2**	--	STA-261-MN: Probability Distributions and Applications (T) STA-262-MN: Minor Statistics Practical – II (P) **Credit-2+2**	STA-266-OE: Practical Based on Applied Statistical Techniques (P) **Credit- 2**	STA-276-SEC: Programming in R and Introduction to Tableau, Power BI (P) **Credit- 2**	MAR-231-AEC: लेखन निर्मिती व परीक्षण कौशल्ये (T) **Or** HIN-231-AEC: हिंदी भाषा: संप्रेषण कौशल (T) **Or** SAN-231-AEC: प्रगत संभाषणकौशल्यम् (T) **Credit- 2**	YOG/PES/CUL/NSS/NCC-289-CC: (T) To be selected from the Basket **Credit- 2**	STA-285-CEP: Community Engagement Project (P) **Credit-2**	
	Cum Cr.	16	--	8	4	4	6	6	2	

Course Structure for F.Y.B.Sc. Statistics (2023 Pattern)

Sem	Course Type	Course Code	Course Name	Theory / Practical	Credits
I	Major Mandatory	STA-101-MJM	Descriptive Statistics – I	Theory	02
	Major Mandatory	STA-102-MJM	Discrete Probability and Probability Distributions – I	Theory	02
	Major Mandatory	STA-103-MJM	Statistics Practical – I	Practical	02
	Open Elective (OE)	STA-116-OE	Commercial Statistics	Theory	02
	Open Elective (OE)	STA-117-OE	Introduction to MS-Excel and Statistical Computing	Practical	02
	Vocational Skill Course (VSC)	STA-121-VSC	Introduction to R Programming Language	Theory	02
	Skill Enhancement Course (SEC)	STA-126-SEC	Statistical Computing Using MS-Excel	Practical	02
	Ability Enhancement Course (AEC)	ENG-131-AEC	Functional English-I	Theory	02
	Value Education Course (VEC)	ENV-135-VEC	Environmental Science	Theory	02
	Indian Knowledge System (IKS)	STA-137-IKS	Evolution of Science and Statistics in India	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
				Total Credits Semester-I	**22**
II	Major Mandatory	STA-151-MJM	Descriptive Statistics – II	Theory	02
	Major Mandatory	STA-152-MJM	Discrete Probability and Probability Distributions – II	Theory	02
	Major Mandatory	STA-153-MJM	Statistics Practical – II	Practical	02
	Minor	STA-161-MN	Fundamental of Statistics	Theory	02
	Open Elective (OE)	STA-166-OE	Business Statistics	Theory	02
	Open Elective (OE)	STA-167-OE	Statistics Learning with Software	Practical	02
	Vocational Skill Course (VSC)	STA-171-VSC	Data Analysis with R Software	Practical	02
	Skill Enhancement Course (SEC)	STA-176-SEC	Application of Statistics Using Advanced Excel	Practical	02
	Ability Enhancement Course (AEC)	ENG-181-AEC	Functional English-II	Theory	02
	Value Education Course (VEC)	COS-185-VEC	Digital and Technological Solutions	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
				Total Credits Semester-II	**22**
				Cumulative Credits Semester I + Semester II	**44**

Course Structure for S.Y.B.Sc. Statistics (2023 Pattern)

Sem	Course Type	Course Code	Course Name	Theory / Practical	Credits
III	Major Mandatory	STA-201-MJM	Continuous Probability Distributions – I	Theory	02
	Major Mandatory	STA-202-MJM	Statistical Techniques – I	Theory	02
	Major Mandatory	STA-203-MJM	Applied Statistics – I	Theory	02
	Major Mandatory	STA-204-MJM	Statistics Practical – III	Practical	02
	Minor	STA-211-MN	Foundations of Probability: Theory and Applications	Theory	02
	Minor	STA-212-MN	Minor Statistics Practical – I	Practical	02
	Open Elective (OE)	STA-216-OE	Applied Statistical Techniques	Theory	02
	Vocational Skill Course (VSC)	STA-221-VSC	Quantitative Techniques	Theory	02
	Ability Enhancement Course (AEC)	MAR-231-AEC HIN-231-AEC SAN-231-AEC	भाषिक उपयोजन व लेखन कौशल्ये हिंदी भाषा कौशल प्राथमिक संभाषणकौशल्यम्	Theory	02
	Field Project (FP)	STA-235-FP	Project	Practical	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC-239-CC	To be selected from the Basket	Theory	02
	Generic IKS Course (IKS)	GEN-245-IKS	Indian Knowledge System (Generic)	Theory	02
				Total Credits Semester-II	**24**
IV	Major Mandatory	STA-251-MJM	Continuous Probability Distributions – II	Theory	02
	Major Mandatory	STA-252-MJM	Statistical Techniques – II	Theory	02
	Major Mandatory	STA-253-MJM	Applied Statistics – II	Theory	02
	Major Mandatory	STA-254-MJM	Statistics Practical – IV	Practical	02
	Minor	STA-261-MN	Probability Distributions and Applications	Theory	02
	Minor	STA-262-MN	Minor Statistics Practical – II	Practical	02
	Open Elective (OE)	STA-266-OE	Practical Based on Applied Statistical Techniques	Practical	02
	Skill Enhancement Course (SEC)	STA-276-SEC	Programming in R and Introduction to Tableau, Power BI	Practical	02
	Ability Enhancement Course (AEC)	MAR-281-AEC HIN-281-AEC SAN-281-AEC	लेखन निर्मिती व परीक्षण कौशल्ये हिंदी भाषा: संप्रेषण कौशल प्रगत संभाषणकौशल्यम्	Theory	02
	Community Engagement Project (CEP)	STA-285-CEP	Community Engagement Project	Practical	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC-289-CC	To be selected from the Basket	Theory	02
				Total Credits Semester-IV	**22**
				Cumulative Credits Semester III + Semester IV	**46**

Course Structure for T.Y.B.Sc. Statistics (2023 Pattern)

Sem	Course Type	Course Code	Course Title	Theory / Practical	Credits
V	Major Mandatory	STA-301-MJM	Distribution Theory – I	Theory	02
	Major Mandatory	STA-302-MJM	Theory of Estimation	Theory	02
	Major Mandatory	STA-303-MJM	Sampling Methods	Theory	02
	Major Mandatory	STA-304-MJM	Design of Experiments	Theory	02
	Major Mandatory	STA-305-MJM	Statistics Practical – V	Practical	02
	Major Elective (MJE)	STA-306-MJE(A)	C- Programming	Theory (Any two)	04
	Major Elective (MJE)	STA-306-MJE(B)	Introduction to Stochastic Processes		
	Major Elective (MJE)	STA-306-MJE(C)	Official Statistics		
	Minor	STA-311-MN	Statistical Techniques – I	Theory	02
	Minor	STA-312-MN	Minor Statistics Practical – III	Practical	02
	Vocational Skill Course (VSC)	STA-321-VSC	Statistical Computing Using R – Software	Practical	02
	Field Project (FP)	STA-335-FP	Field Project	Practical	02
			Total Credits Semester – V		**22**
VI	Major Mandatory	STA-351-MJM	Distribution Theory – II	Theory	02
	Major Mandatory	STA-352-MJM	Testing of Hypothesis	Theory	02
	Major Mandatory	STA-353-MJM	Introduction to Regression Analysis	Theory	02
	Major Mandatory	STA-354-MJM	Operations Research	Theory	02
	Major Mandatory	STA-355-MJM	Statistics Practical – VI	Practical	02
	Major Elective (MJE)	STA-356-MJE(A)	Actuarial Statistics	Theory (Any two)	04
	Major Elective (MJE)	STA-356-MJE(B)	Bio-Statistics		
	Major Elective (MJE)	STA-356-MJE(C)	Ecology		
	Minor	STA-361-MN	Statistical Techniques – II	Theory	02
	Minor	STA-362-MN	Minor Statistics Practical – IV	Practical	02
	On Job Training (OJT)	STA-385-OJT	On Job Training	Practical	04
			Total Credits Semester – VI		**22**
			Total Credits Semester – V + VI		**44**

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Major Mandatory (Theory)
Course Code	**:** STA-351-MJM
Course Title	**:** Distribution Theory – II
No. of Credits	**:** 02
No. of Teaching Hours	**:** 30

Course Objectives:

1. To learn how to apply continuous probability distribution to real world situation.
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 enable students to identify appropriate probability models for real-world data and perform related statistical inferences.
6. To understand the concept, derivation, and applications of truncated distributions in statistical modelling.
7. To study properties and characteristics of Laplace, Lognormal, and Pareto distributions, including their moments and shapes.

Course Outcome:

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

CO1. explain and derive the probability density function, mean, variance, and moment generating function of the Laplace (Double Exponential) distribution and understand its applications.

CO2. analyse and interpret the properties of the Lognormal distribution and apply it to model skewed real-life phenomena such as income or life duration.

CO3. describe the Pareto distribution, its parameters, and its use in modelling wealth, insurance claims, and heavy-tailed data.

CO4. understand and derive properties of the Bivariate Normal distribution, including marginal and conditional distributions, correlation, and regression structure.

CO5. define and work with truncated distributions, derive their moments, and apply them to censored and bounded data situations.

CO6. thoroughly understanding the procedures of probability distributions students can apply these distributions to model random events.

CO7. apply distribution theory to analyze and interpret data patterns, ensuring appropriate statistical analysis and decision-making.

Topics and Learning Points

Unit – 1 Laplace (Double Exponential) Distribution (7L)

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

$= 0 \qquad ; elsewhere$

Notation: X~ L (μ, λ)

1.2 Nature of the probability curve.

1.3 Derivation of distribution function, quartiles.

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

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

1.6 Illustrative examples.

Unit – 2 Lognormal Distribution (7L)

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

$= 0 \qquad ; elsewhere$

Notation: X~ LN (a, μ, σ^2)

2.2 Derivation of relation with N (μ, σ^2) distribution

2.3 Nature of the probability curve.

2.4 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.

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

2.6 Illustrative examples.

Unit – 3 Bivariate Normal Distribution (9L)

3.1 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 $(\mu_1, \mu_2, \sigma_1, \sigma_2, \rho)$

3.2 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 $\frac{X}{Y}$.

3.3 Illustrative examples.

Unit – 4. Truncated Distribution (7L)

4.1 Truncated distribution truncation to the right, left and on both sides.

4.2 Binomial distribution B(n, p) left truncated at X = 0, (value zero is discarded), its p.m.f. mean, variance.

4.2 Poisson distribution P(m), left truncated at X = 0, (value zero is discarded), its p.m.f. mean, variance.

4.3 Normal distribution N (μ, σ^2) truncated to

i) the left below a

ii) the right above b

iii) the left below a and to the right above b , (a < b)

its and derivation of mean and statement (without derivation)of variance.

References:

1. Arora Sanjay and Bansi Lal (1989). Mathematical Statistics (1st Edition), Satya Prakashan 16/17698, New Delhi.
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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.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3				3								
CO2	3	2			3		2						
CO3	3		1		3								
CO4	3	2		3	3		2						
CO5	3	2		3	3		2						
CO6	3	2	1	3	3	2		3	3			2	
CO7	3	2	1	3	3	2	2	3	3	1	1	2	1

PO1: Comprehensive Knowledge and Understanding

- Strongly related (CO1–CO7) as the course deepens understanding of advanced continuous distributions, their derivations, and theoretical properties.

PO2: Practical, Professional, and Procedural Knowledge

- Moderately related (CO2, CO4, CO5, CO6, CO7) since students apply distribution theory in practical data modelling and statistical inference.

PO3: Entrepreneurial Mindset and Knowledge

- Partially related (CO3, CO6, CO7). Knowledge of applied distributions like Lognormal and Pareto enhances data-based decision-making in business, finance, and insurance analytics.

PO4: Specialized Skills and Competencies

- Strongly related (CO4–CO7) as students gain expertise in modeling complex data using bivariate and truncated distributions.

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

- Strongly related (CO1–CO7). The course develops critical thinking and analytical skills for solving real-world problems using statistical models.

PO6: Communication Skills and Collaboration

- Moderately related (CO6–CO7). Interpretation and presentation of distribution-based findings foster clear communication of statistical results.

PO7: Research-related Skills

- Moderately related (CO2, CO4, CO5, CO7) as students use theoretical distributions for data analysis, simulation, and model fitting in research contexts.

PO8: Learning How to Learn Skills

- Strongly related (CO6–CO7). Students develop independent learning through derivation, interpretation, and comparison of distributions.

PO9: Digital and Technological Skills

- Strongly related (CO6–CO7). Students apply software (R, Python, etc.) to analyze and visualize probability distributions.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Partially related (CO7). Application of data modelling to societal and economic studies enhances understanding of diversity in data patterns.

PO11: Value Inculcation and Environmental Awareness

- Partially related (CO7). Awareness of modelling uncertainty in environmental or economic data fosters responsible analysis.

PO12: Autonomy, Responsibility, and Accountability

- Moderately related (CO6–CO7). Independent analysis of data distributions enhances self-directed and responsible research.

PO13: Community Engagement and Service

- Partially related (CO7). Application of statistical knowledge to social, economic, and health data promotes community-oriented research and service.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Major Mandatory (Theory)
Course Code	**:** STA-352-MJM
Course Title	**:** Testing of Hypothesis
No. of Credits	**:** 02
No. of Teaching Hours	**:** 30

Course Objectives:

1. To develop a thorough understanding of interval estimation by constructing and interpreting confidence intervals for population parameters.
2. To acquire knowledge of parametric hypothesis testing procedures and their applications in real-world problem-solving.
3. To understand the theoretical foundations and practical applications of Sequential Probability Ratio Tests, focusing on their efficiency and decision-making advantages over fixed-sample tests.
4. To familiarize students with non-parametric statistical methods as alternatives to parametric tests, highlighting situations where they are appropriate.
5. To cultivate the ability to select appropriate inferential procedures (interval estimation, parametric, sequential, or non-parametric tests) based on data characteristics and assumptions.
6. To strengthen problem-solving and analytical skills through the application of inferential techniques to datasets, interpreting results, and drawing valid conclusions.
7. To prepare students for advanced research and professional practice by developing a critical understanding of statistical inference methods and their role in scientific investigation.

Course Outcomes:

On successful completion of this course, the students will be able to:

CO1. explain the concepts of interval estimation and construct confidence intervals for parameters under different probability models.

CO2. apply parametric tests for hypothesis testing in real-life situations and evaluate their validity.

CO3. differentiate between one-sample and two-sample tests in parametric frameworks, and interpret their outcomes.

CO4. understand the principles of sequential probability ratio tests and demonstrate their application in decision-making problems.

CO5. analyze and apply non-parametric tests such as run test, sign test, rank-sum test, and Kruskal-Wallis test when assumptions of parametric tests are not satisfied.

CO6. evaluate the strengths, limitations, and applicability of parametric, non-parametric, and sequential tests in various statistical contexts.

CO7. develop problem-solving skills by formulating hypotheses in case of nonparametric tests, selecting appropriate inference techniques, and drawing valid statistical conclusions.

Topics and Learning Points

Unit 1: Interval Estimation (5 L)

1.1 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.

1.2 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

Unit 2: Parametric Tests (10 L)

2.1 Statistical hypothesis, review of hypotheses, types of hypothesis and critical region. Definition of Type I and Type II errors. Probabilities of type I error and type II error. Problem of controlling the probabilities of errors of two kinds. Definition of level of significance, p-value, size of a test

2.2 MP and UMP Tests: Definition of most powerful (M.P.) level α test of simple null hypothesis against simple alternative. Statement of *Neyman - Pearson* lemma for constructing the most powerful level α test of simple null hypothesis against simple alternative hypothesis. Illustrations. Power function of a test, power curve, definition of uniformly most powerful (UMP) level α test for one sided alternative. Illustrations

Unit 3: Sequential Probability Ratio Tests (6L)

Sequential test procedure for simple null hypothesis against simple alternative hypothesis and its comparison with fixed sample size N-P test procedure. Definition of Wald's SPRT of strength (α, β). Illustration for standard distributions like Bernoulli, Poisson, Normal and Exponential. SPRT as a function of sufficient statistics.

Unit 4: Non-Parametric Tests (9L)

4.1 Concept of non- parametric tests. Distinction between a parametric and a nonparametric Tests. Concept of distribution free statistic.

4.2 Nonparametric Tests:

i) Run test one sample and two samples problems.

ii) Sign test

iii) Wilcoxon signed rank test

iv) Mann- Whitney U test

v) Kolmogorov–Smirnov test for completely specified univariate distribution (one Sample problem only)

References:

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2. Arora, S. and Bansi Lal. (1989): New Mathematical Statistics, first edition, Satya Prakashan, New Delhi.
3. Daniel, W.W. (2000) Applied Nonparametric Statistics, Duxbury Press Boston.
4. Dudeweitz, E.J. and Mishra, S.N. (1988). Modern Mathematical Statistics, John Wiley and Sons, Inc
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6. Hoel, P.G.,Port, S. and Stone, C. (1971). Introduction to Statistical Theory, Houghton Mifflin Company (International) Dolphin
7. Hogg, R.V. and Craig, R.G. (1989). Introduction to Mathematical Statistics (fourth edition, Collier Macmillan International Edition, Macmillan Publishing Co. Inc., New York.
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Statistics (third edition) International Student Edition, McGraw Hill.

13. Rohatgi, V.K. (1976). An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.

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COs and POs Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**
CO1	3	1		1	2		3	1					
CO2	3	2		3	3	1	3	1	2			1	
CO3	3	2		3	3	1	2	1	1			1	
CO4	3	2		2	2		3	1	1				
CO5	3	2		3	3	1	3	1	2			1	
CO6	3	2		3	3	2	2	2	1	1	1	2	
CO7	2	2	1	3	3	2	3	2	2	1	1	2	1

CO–PO Mapping with Justifications

PO1. Comprehensive Knowledge and Understanding

- Strongly related to CO1, CO2, CO3, CO4, CO5, CO6 since these cover fundamental theories of inference.
- Weightage: **3** wherever basic understanding and conceptual clarity is emphasized.

PO2. Practical, Professional, and Procedural Knowledge

- Moderately related to CO2, CO3, CO4, CO5, CO7 since students apply statistical tests in real-life cases.
- Weightage: **2** where procedural and applied knowledge is demonstrated.

PO3. Entrepreneurial Mindset and Knowledge

- Partially related to CO7**,** since applying inference tools may support decision-making and innovation in real-world/entrepreneurial settings.
- Weightage: **1**.

PO4. Specialized Skills and Competencies

- Strongly related to CO2, CO3, CO5, CO6, CO7**,** as these emphasize analytical reasoning, problem-solving, and interpreting outcomes.
- Weightage: **3**.

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

- Strongly related to CO2, CO3, CO5, CO6, CO7**,** since students must apply appropriate tests, interpret results, and solve statistical problems.
- Weightage: **3**.

PO6. Communication Skills and Collaboration

- Moderately related to CO6, CO7 as students communicate test results, collaborate in problem-solving, and report interpretations.
- Weightage: **2**.

PO7. Research-related Skills

- Strongly related to CO1, CO2, CO4, CO5, CO7**,** as students will frame hypotheses, apply tests, and interpret results in research contexts.
- Weightage: **3**.

PO8. Learning How to Learn Skills

- Moderately related to CO6, CO7, as students adapt and learn when to use parametric, non-parametric, or sequential tests.
- Weightage: **2**.

PO9. Digital and Technological Skills

- Moderately related to CO2, CO5, CO7, since software tools (e.g., R, SPSS) may be used for implementation.
- Weightage: **2**.

PO10. Multicultural Competence, Inclusive Spirit, and Empathy

- Not directly related; at best partially related (1) to CO6, CO7**,** when working in diverse teams or interpreting data in social contexts.

PO11. Value Inculcation and Environmental Awareness

- Indirect relation, but partially related (1) to CO7, where ethical data handling and responsible inference are emphasized.

PO12. Autonomy, Responsibility, and Accountability

- Moderately related to CO6, CO7, since students must independently select tests and justify their conclusions responsibly.
- Weightage: **2**.

PO13. Community Engagement and Service

- Partially related to CO7**,** since applying statistical inference in community/social research can enhance societal well-being.
- Weightage: **1**.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme : B.Sc. Statistics

Programme Code : USST

Class : T.Y.B.Sc.

Semester : VI

Course Type : Major Mandatory (Theory)

Course Code : STA-353-MJM

Course Title : Introduction to Regression Analysis

No. of Credits : 02

No. of Teaching Hours : 30

Course Objectives:

1. The main objective of regression analysis is to explain the variation in one variable based on the variation in one or more other variables
2. The students will able to develop a deeper understanding of the linear regression model and its limitations.
3. Students will know how to diagnose and apply corrections to some problems with the linear and multiple regression models in real data.
4. The students will be able to learn and understand various regression models.
5. The students will be able to understand the concept of logistic regression and its application in real world problems.
6. Apply regression techniques to solve real world problems in various fields
7. Analyze and interpret data using regression methods and present findings in a clear and concise manner.

Course Outcome:

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

CO 1. Students will be able to understand basic assumption and various terms of regression model.

CO 2. The students should able to demonstrate simple linear regression as a tool for exploring the linear relationship between two variables

CO 3. Students will learn how to estimate and interpret the model.

CO 4. Once student understand the model, they will explore how to evaluate the model.

CO 5. Students will also list the assumptions underlying the simple linear regression model and use graphical and numerical methods to check the assumptions.

CO 6. Students will learn about using variable transformations and interactions to incorporate nonlinear relationships in the model.

CO 7. Students will be able to apply Simple Linear Regression model, Multiple Linear Regression Analysis, Logistic Regression Model in real life problems.

Topics and Learning Points

Unit-1 Simple Linear Regression **(7L)**

1.1 Introduction to Regression Analysis as a statistical tool

1.2 Review of simple linear regression model: $Y = \beta_0 + \beta_1 X + \varepsilon$, where ε is a continuous random variable with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$.

1.3 Estimation of β_0 and β_1, by the method of least squares.

1.4 Properties of estimators of β_0, and β_1

1.5 Estimation of σ^2

1.6 Assumption of normality of ε. Tests of hypothesis of β_1

1.7 Interval estimation in simple linear regression model

1.8 Coefficient of determination

1.9 Examples and illustrations.

Unit-2 Multiple Linear Regression Model **(7L)**

2.1 Review of multiple linear regression model $Y = \beta_0 + \beta_1 X_1 + \ldots + \beta_k X_k + \varepsilon$, where ε is a continuous random variable with $E(\varepsilon) = 0$, $V(\varepsilon) = \sigma^2$. Estimation of regression parameters $\beta_0, \beta_1, \ldots, \beta_k$ by the method of least squares, Obtaining normal equations, solutions of normal equations

2.2 Estimation of σ^2

2.3 Assumption of normality of ε. Tests of hypothesis of Regression parameters

2.4 Assessing adequacy of model

2.5 Test of significance of regression

2.6 Test of individual regression coefficient

2.7 Coefficient of determination

2.8 Interval estimation in multiple linear regression models

2.9 Examples and illustrations.

Unit-3 Regression Diagnostics and Model Building **(6 L)**

3.1. Residual Analysis, Residual plots

3.2. Interpretation of four plots produced by lm command in R

3.3. Corrective measures

3.4. Outliers: Detection

3.5. Detection of Multicollinearity and computation of VIF

3.6. Examples and illustrations.

Unit-4 Variable Selection and Model Building (4L)

4.1 The model building problem

4.2 Consequences of model Misspecification

4.3 Criteria for evaluating subset regression models

4.4 Examples and illustrations.

Unit-5 Logistic Regression Model (6L)

5.1. Introduction

5.2. Univariate logistic regression model

5.2.1 Defining the logistic regression model

5.2.2 Fitting the logistic regression model

5.2.3 Interpretation of parameters

5.2.4 Testing of hypothesis in Logistic Regression

5.3 Multiple logistic regression model.

5.3.1 Fitting the logistic regression model

5.3.2 Interpretation of parameters

5.3.3 Testing of hypothesis in Logistic Regression

5.4 AIC and BIC criteria for model selection.

5.5 Interpretation of output produced by glm command in R

5.6 Examples and illustrations.

References:

1. Draper, N. R. and Smith, H. (1998) Applied Regression Analysis (John Wiley) Third Edition.
2. Hosmer, D. W. and Lemeshow, S. (1989) Applied Logistic Regression (Wiley).
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Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**
CO1	3	-						2					1
CO2	3	3		2	3	2		2					1
CO3	3	3		2	3	2	2	2					1
CO4	3	3		2	3	2	2	2	3				1
CO5	3	3		2	3	2	2	2	3				1
CO6	3	3		2	3	2	2	2	3				1
CO7	3	3	1	2	3	2	2	2	3	1	1	2	2

PO1: Comprehensive Knowledge and Understanding

- Students develop a strong theoretical foundation in regression models, assumptions, estimation, and interpretation.
- Strongly related (3) to CO1–CO7 as it covers conceptual understanding of regression theory.

PO2: Practical, Professional, and Procedural Knowledge

- Students apply regression techniques using real datasets and statistical software, aligning with professional practices.
- Strongly related (3) to CO2–CO7 due to practical application and interpretation.

PO3: Entrepreneurial Mind-set and Knowledge

- Regression analysis enables data-driven decision-making, supporting innovation and business applications.
- Partially related (1) for CO7 (application-based).

PO4: Specialized Skills and Competencies

- Students develop analytical, technical, and communication skills by interpreting regression results and presenting findings.
- Moderately related (2) for CO2–CO7.

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

- Regression modeling fosters analytical reasoning and problem-solving in real-life contexts.
- Strongly related (3) across CO2–CO7.

PO6: Communication Skills and Collaboration

- Students interpret and present regression outputs through reports and teamwork, improving communication and collaboration.
- Moderately related (2) across CO2–CO7.

PO7: Research-related Skills

- Students learn data handling, model fitting, assumption checking, and evaluation—key components of research methodology.
- Moderately related (2) for CO3–CO7.

PO8: Learning How to Learn Skills

- Students engage in self-learning while applying new regression techniques and understanding model diagnostics.
- Moderately related (2**)** to all COs.

PO9: Digital and Technological Skills

- Students use statistical tools (R, Python, SPSS, etc.) for model fitting and validation.
- Strongly related (3) for CO4–CO7.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- While regression is technical, interpreting social or community datasets promotes inclusivity and empathy.
- Partially related (1) for CO7.

PO11: Value Inculcation and Environmental Awareness

- Regression can be applied in sustainable and ethical research projects (e.g., environment, health, education).
- Partially related (1) for CO7.

PO12: Autonomy, Responsibility, and Accountability

- Students perform independent data analysis and report findings responsibly.
- Moderately related (2) for CO7.

PO13: Community Engagement and Service

- Regression models can analyze social, health, and educational issues, promoting societal welfare.
- Partially related (1) for CO7.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Major Mandatory (Theory)
Course Code	**:** STA-354-MJM
Course Title	**:** Operations Research
No. of Credits	**:** 02
No. of Teaching Hours	**:** 30

Course Objectives:

1. To introduce the concepts of project planning and control using Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT).
2. To understand the principles and mathematical formulation of inventory models for effective inventory management.
3. To acquaint students with decision-making techniques under conditions of risk and uncertainty.
4. To develop analytical skills in evaluating replacement policies for deteriorating items or equipment.
5. To enhance students' ability to apply quantitative and statistical reasoning to real-life management, industrial, and production problems.
6. To understand PERT and CPM network techniques and difference between them.
7. To integrate various operations research models to optimize resources, minimize costs, and enhance managerial decision-making.

Course Outcomes:

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

CO1. construct project networks using CPM and PERT, compute earliest and latest times, identify critical paths, and determine project duration.

CO2. know essential difference between PERT and CPM network techniques.

CO3. apply probabilistic concepts to estimate the likelihood of project completion within a specified time using PERT analysis.

CO4. explain various inventory classification techniques (ABC, VED, FNSD) and their role in effective inventory control.

CO5. derive and interpret classical inventory models under different assumptions of

demand, replenishment rate, and shortage conditions.

CO6. apply decision-making criteria such as Expected Value, Laplace, Minimax, Hurwitz, and Savage criteria to problems involving uncertainty and risk.

CO7. analyze and develop replacement policies for items that deteriorate over time under both constant and variable money value assumptions.

Topics and Learning Points

Unit-1 Critical Path Method (CPM) and Project Evaluation and Review Techniques (PERT) (10L)

1.1 Definition of (i) Event, (ii) Node, (iii) Activity, (iv) Critical Activity, (v) Project Duration.

1.2 CPM: Construction of network, Definitions

(i) earliest start time

(ii) earliest finish time

(iii) latest start time

(iv) latest finish time for an activity.

1.3 Critical Path, Types of floats, total floats, free float, independent float and their significance. Determination of critical path

1.4 PERT: Construction of network; (i) pessimistic time estimate, (ii) optimistic time estimate (iii) most likely time estimates, Determination of critical path, determination of mean and standard deviation of project duration, computations of probability of completing the project in a specified duration.

Unit-2 Inventory Models (8L)

2.1 Always Better Control (ABC) Analysis; Vital, Essential and Desirable (VED) Analysis; Fast moving, Non moving, Slow moving, Dead (FNSD) Analysis.

2.2 Description of generalized inventory model.

2.3 Type of Inventory Models:

a) The Economic Lot Size Model with uniform demand, instantaneous replenishment rate and no shortage (without derivation)

b) The Economic Lot Size Model with uniform rate of demand, finite replenishment rate and no shortage (without derivation)

c) The Economic Lot Size Model with uniform demand instantaneous replenishment rate with shortage (without derivation)

d) The economic lot size model with uniform rate of demand, finite replenishment rate with Shortage (without derivation)

Unit-3 Decision Theory (7L)

3.1 Decision under risk: Expected Value Criteria

3.2 Decision Trees

3.3 Decision Under Uncertainty

a) Laplace Criterion
b) Minimax / Maximax criterion
c) Savage minimax regret criterion
d) Hurwitz criterion

Unit-4 Replacement Models (5L)

4.1 Introduction

4.2 Replacement of item that deteriorates with time when

a) Value of money remains same during the period (for time as a discrete variable and (continuous variable).
b) Value of money changes with constant rate during the period.

References:

1. Gass E.: Linear Programming Method and Application, Narosa Publishing House, New Delhi.

2. Taha, R. A.: Operation Research – An Introduction, Fifth Edition, Prentice Hall of India, New Delhi.

3. Saceini Yaspan, Friedman: Operation Research Method and Problem, Wiley International Edition.

4. Shrinath L.S.: Linear Programming Affiliated East- West press Pvt. Ltd. New Delhi.

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9. Shrinath, L.S.: PERT-CPM Principal and Application Affiliated East-West Press Pvt. Ltd., New Delhi.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	3	2	3	3	2	2	2	2	1	1	3	1
CO2	3	3	2	3	3	2	2	2	2	1	1	3	1
CO3	3	3	2	3	3	2	2	2	2	1	1	3	1
CO4	3	3	2	3	3	2	2	2	2	1	1	3	1
CO5	3	3	2	3	3	2	2	2	2	1	1	3	1
CO6	3	3	2	3	3	2	2	2	2	1	1	3	1
CO7	3	3	2	3	3	2	2	2	2	1	1	3	1

Justification:

PO1: Comprehensive Knowledge and Understanding

- Strongly related to all COs. The course imparts conceptual understanding of key quantitative techniques—CPM, PERT, Inventory, Decision, and Replacement Models—enabling students to comprehend project scheduling, resource optimization, and decision-making under uncertainty.

PO2: Practical, Professional, and Procedural Knowledge

- Strongly related. Students acquire hands-on skills in constructing project networks, deriving EOQ models, and applying decision criteria practical procedures widely used in management, production, and research domains.

PO3: Entrepreneurial Mindset and Knowledge

- Moderately related. Knowledge of inventory control, cost optimization, and replacement policies promotes efficient resource management and fosters an entrepreneurial and managerial approach to decision-making.

PO4: Specialized Skills and Competencies

- Strongly related. The course equips students with analytical and mathematical modelling skills essential for professional decision analysis, project evaluation, and logistics management.

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

- Strongly related. All COs develop analytical reasoning by applying models to solve real-world problems such as minimizing project duration, optimizing stock levels, and evaluating alternative decisions.

PO6: Communication Skills and Collaboration

- Moderately related. Group-based problem solving and presentation of solutions (e.g., project network diagrams or decision trees) enhance communication and collaborative abilities.

PO7: Research-related Skills

- Moderately related. Students interpret probabilistic project completion times and use optimization models—skills useful for applied research and data-driven problem solving.

PO8: Learning How to Learn Skills

- Moderately related. Understanding diverse models encourages independent learning and adaptability in solving new and complex operational problems.

PO9: Digital and Technological Skills

- Moderately related. CPM–PERT and inventory problems can be solved using computational tools such as Excel, Python, or R, strengthening digital analytical competence.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Partially related. Decision theory applications often involve consideration of multiple stakeholder perspectives, promoting inclusive and balanced decision-making.

PO11: Value Inculcation and Environmental Awareness

- Partially related. Models like replacement and inventory optimization foster efficient resource utilization and cost-effective, sustainable operations.

PO12: Autonomy, Responsibility, and Accountability

- Strongly related. The course encourages self-directed learning, responsible modelling, and accountable decision-making based on quantitative evidence.

PO13: Community Engagement and Service

- Partially related. Application of operational and decision models to public and social projects develops awareness of community-oriented solutions and services.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Major Mandatory (Practical)
Course Code	**:** STA-355-MJM
Course Title	**:** Statistics Practical – VI
No. of Credits	**:** 02
No. of Teaching Hours	**:** 60

Course Objectives:

1. To learn and understand various regression models, like simple linear regression model, multiple linear regression model, polynomial regression model, logistic regression model, etc.
2. To estimate the parameters of the regression model and perform residual diagnostics.
3. To find an appropriate subset of regressors for the model.
4. To measure the relationship between a categorical dependent variable and one or more independent variables.
5. To differentiate between parametric and non-parametric tests.
6. To understand hypothesis testing using parametric test and non-parametric test, including calculation of test statistics and p values.
7. To understand the concept of Type I Error, Type II Error, construct power functions and level of significance for a hypothesis testing.

Course Outcome:

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

CO 1. interpret the regression model and predict the response variable.

CO 2. determine critical path and floats associated with non- critical activities and events along with total project completion time.

CO 3. understand the importance of using PERT and CPM techniques for project management.

CO 4. formulate regression models based on practical problems and research questions.

CO 5. apply techniques for variable selection, including stepwise regression and regularization methods.

CO 6. understand and apply logistic regression for binary and multinomial outcomes.

CO 7. use of Statistical Hypothesis in real life situations.

Topics and Learning Points

Sr. No.	Title of Experiments
1	Fitting of Lognormal Distribution.
2	Model Sampling from Cauchy and Laplace Distribution.
3	Variable Selection and Model Building- I (Forward Selection, Backward Elimination)
4	Logistic Regression
5	Critical Path Method (CPM) and Project Evaluation and Review Techniques (PERT)
6	Testing of hypothesis- I (Probability of type I error and type II error, power of a test)
7	Testing of hypothesis (Construction of MP and UMP test, plotting of power function of a test)
8	Non- parametric tests- I (Sign test, Wilcoxon's signed rank test, Mann-Whitney U test)
9	Non- parametric tests- II (Run test, median test, Kolmogorov- Smirnov test)
10	SPRT- I (Bernoulli, Binomial, Poisson, Hypergeometric Distributions)
11	SPRT- II (Normal, Exponential Distribution)
12	Case Study (Equivalent 3 Practicals)

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	**Programme Outcomes (POs)**												
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PO13**
CO1	3	3	2	3	3	2		3	3	1	1	3	1
CO2	3	3	2	3	3	2		3	3	1	1	3	1
CO3	3	3	2	3	3	2		3	3	1	1	3	1
CO4	3	3	2	3	3	2	3	3	3	1	1	3	1
CO5	3	3	2	3	3	2	3	3	3	1	1	3	1
CO6	3	3	2	3	3	2	3	3	3	1	1	3	1
CO7	3	3	2	3	3	2	3	3	3	1	1	3	1

PO1: Comprehensive Knowledge and Understanding

- Strongly related to all COs as students gain in-depth conceptual understanding of regression models, hypothesis testing, and project management techniques like CPM and PERT.

PO2: Practical, Professional, and Procedural Knowledge

- Strongly related. Students learn structured methods for project analysis (CPM/PERT), statistical modeling (regression), and hypothesis testing applicable in professional and research contexts.

PO3: Entrepreneurial Mindset and Knowledge

- Moderately related. Skills in prediction, optimization, and time management promote data-driven decision-making and efficient resource utilization in entrepreneurial projects.

PO4: Specialized Skills and Competencies

- Strongly related. Students develop specialized abilities in regression diagnostics, variable selection, and logistic regression, essential for applied data science and analytics.

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

- Strongly related. The course enhances analytical thinking through model formulation, parameter estimation, project time optimization, and hypothesis testing.

PO6: Communication Skills and Collaboration

- Moderately related. Interpretation of regression results, project plans, and hypothesis conclusions demands clarity in statistical communication and teamwork.

PO7: Research-related Skills

- Strongly related through CO4–CO7. Students learn how to design regression models, test hypotheses, and use data-driven approaches for research applications.

PO8: Learning How to Learn Skills

- Strongly related. Continuous learning through interpreting models, applying new statistical tools, and evaluating project management techniques fosters independent learning.

PO9: Digital and Technological Skills

- Strongly related. Application of software such as R, or Excel in regression modeling and CPM–PERT calculations enhances technological proficiency.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Partially related. Regression and project management tools can be applied to diverse real-world contexts, promoting inclusive and balanced decision-making.

PO11: Value Inculcation and Environmental Awareness

- Partially related. Applying statistical models for sustainable development, efficient resource use, and project planning fosters responsible decision-making.

PO12: Autonomy, Responsibility, and Accountability

- Strongly related. Students develop self-reliance in conducting data analysis, managing projects, and interpreting results with accountability.

PO13: Community Engagement and Service

- Partially related. The ability to apply analytical and project management techniques can contribute to social, environmental, and community-based initiatives.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme : B.Sc. Statistics

Programme Code : USST

Class : T.Y.B.Sc.

Semester : VI

Course Type : Major Elective (Theory)

Course Code : STA-356-MJE(A)

Course Title : Actuarial Statistics

No. of Credits : 02

No. of Teaching Hours : 30

Course Objectives:

1. To learn and understand various concepts involved in Actuarial Statistics.
2. To provide students with a foundational understanding of actuarial science and its role in risk assessment, management, and financial planning.
3. To cover the principles of life insurance and annuities, including mortality tables, premium calculations, and reserve valuation.
4. To apply appropriate modelling techniques for lifetime random variables involved in the field of Insurance.
5. To apply the fundamental theories of actuarial statistics as they apply in life insurance, endowment insurance, n-year term life insurance.
6. To provide an overview of actuarial models used in pricing insurance products, such as the single premium, net premium, and gross premium.
7. To provide real-world case studies and practical exercises that allows students to apply actuarial principles and techniques to solve practical problems.

Course Outcomes:

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

CO 1. identify and analyse consequences of events involving risk and uncertainty.

CO 2. calculate survival function, curtate future lifetime, force of mortality.

CO 3. calculate various payments from life tables using principle of equivalence, net premiums, prospective and retrospective reserve.

CO 4. understand the principles of risk management and how they apply to actuarial practice.

CO 5. gain insights into the insurance and financial industries, including current trends, challenges, and opportunities.

CO 6. apply actuarial techniques to real-world scenarios and case studies.

CO 7. explore ethical considerations and responsibilities in the actuarial profession.

Topics and Learning Points

Unit-1: Insurance Business **(4L)**

1.1 Insurance companies as business organizations.

1.2 Role of insurance business in Economy.

1.3 Concept of risk, types of risk, characteristics of insurable risk.

1.4 Working of insurance business, introduction of terms such as premium, policy, policyholder and benefit.

1.5 Role of Statistics in insurance and insurance business in India.

Unit-2: Feasibility of Insurance Business **(4L)**

2.1 Measurement of adverse financial impact, expected value principle.

2.2 Concept of utility function

2.3 Feasibility of insurance business.

2.4 Illustrative examples.

Unit-3 : Survival Distribution and Life Tables **(6L)**

3.1 Time- until death random variable, its d.f. and survival function in actuarial notation.

3.2 Force of mortality.

3.3 survival function, force of mortality and p.d.f.

3.4 Curtate future life random variable, its p.m.f. and survival function in actuarial notation.

3.5 Construction of life table using random survivorship approach.

Unit-4 : Models for Life Insurance **(6L)**

4.1 Theory of compound interest, effective rate of interest, discount factor.

4.2 Insurance payable at the end of the year of death, present value random variable, actuarial present value.

4.3 Derivation of actuarial present value for n-year term life insurance, whole life insurance and endowment insurance.

Unit-5: Annuity **(5L)**

5.1 Annuities – certain, annuity due, annuity immediate.

5.2 Discrete life annuities: n-year temporary life annuity due and a whole life annuity due, present value random variables of the payment, and their actuarial present values.

Unit- 6: Benefit Premiums **(5L)**

6.1 Concept of a loss at issue random variable.

6.2 Equivalence principle

6.3 Computation of fully discrete premium for n-year term life insurance, whole life insurance and endowment insurance.

6.4 Variance of loss random variable.

References:

1. Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, 2nd Edition, the Society of Actuaries.
2. Deshmukh S.R. (2024). Actuarial Statistics: An Introduction Using R, Second edition Universities Press.
3. Actuarial Mathematics, Society of Actuaries, ltasca, lllinois, U.S.A. 2nd Edition (1997).
4. Spurgeon E.T. (1972); Life Contingencies, Cambridge University Press. Neill, A. Life Contingencies, Heinemann.

COs and POs Mapping

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3		1		3								
CO2	3		1		3								
CO3	3	3	1	1	3							3	
CO4		3	1	1	3	2		1		1	3	3	
CO5			1		3	2		1	2	1	3	3	2
CO6	3	3	1	1	3	2	3	1	2	1	3	3	2
CO7			1			2	3	1	2	1	3	3	2

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

Justifications by Program Outcome (PO)

PO1 – Comprehensive Knowledge

Strongly aligned with CO1 to CO3, CO6, where students build a foundational understanding of actuarial science, life tables, risk, and survival functions.

PO2 – Practical, Professional, and Procedural Knowledge

CO3, CO4, CO6 score highly due to application of actuarial formulas and methodologies in professional contexts.

PO3 – Entrepreneurial Mindset

Most COs are partially related (1); CO4, CO5, CO6, CO7 reflect understanding of business risks and insurance markets, adding a moderate (2–3) entrepreneurial alignment.

PO4 – Specialized Skills and Competencies

Partially related (1): CO3, CO4, CO6 involve analytical modeling and real-world applications in insurance, risk, and finance.

PO5 – Application, Problem-Solving, and Analytical Reasoning

CO1 to CO6 are all highly analytical and problem-solving focused.

PO6 – Communication Skills and Collaboration

Moderate mapping, particularly in CO4 to CO7, where students are expected to understand and communicate actuarial insights effectively.

PO7 – Research-related Skills

Strongly linked with CO6 and CO7, as they involve critical evaluation, case studies, and ethical reasoning.

PO8 – Learning to Learn

Partially related (1): CO4 to CO7 require self-directed learning, understanding market trends, and applying evolving techniques.

PO9 – Digital and Technological Skills

Moderate (2), especially in CO5 to CO7, where actuarial tools and software are often used.

PO10 – Multicultural Competence, Empathy

Partially related (1) where societal and ethical dimensions of risk/insurance are discussed (CO4–CO7).

PO11 – Ethics and Environmental Awareness

Strong in CO4–CO7, which explore professional responsibility and ethical decision-making in insurance/finance.

PO12 – Autonomy, Responsibility, Accountability

Strongly present in CO3–CO7, as students work independently on financial modeling, risk evaluation, and ethical issues.

PO13 – Community Engagement

Moderate alignment, especially in CO5–CO7, where actuarial knowledge impacts community wellbeing (insurance design, pensions, etc.).

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme : B.Sc. (Statistics)
Programme Code : USST
Class : T.Y.B.Sc.
Semester : VI
Course Type : Major Elective (Theory)
Course Code : STA-356-MJE(B)
Course Title : Bio-Statistics
No. of Credits : 02
No. of Teaching Hours : 30

Course Objectives:

1. To learn and understand a basic concept of emerging branch of clinical trials belongs to biostatistics.
2. To understand the principles of epidemiology and discussion of the concept of natural history of disease particularly with respect to possible clinical interventions.
3. To understand the phases of clinical trials and the types of study designs typically used in clinical trials, use of randomization and blinding.
4. To understand the purposes for conducting clinical trials.
5. To develop skills in estimation and interpretation of odds ratio (OR) and confidence intervals.
6. To interpret and critically analyze clinical study reports and statistical analysis plans.
7. To explain the concepts of bioequivalence and bioavailability and their role in non-inferiority trials, along with the principles of practice-based medical research.

Course Outcomes:

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

CO1. understand the basic concept of clinical trials.
CO2. identify epidemic events in real life situations.
CO3. understand the designs which typically used in clinical trials.
CO4. apply appropriate design from clinical trials.
CO5. use descriptive statistical methods to summarize and present data in the context of biological and health sciences.

CO6. understand the fundamental principles and phases of clinical trials, including their design, conduct, and regulatory aspects.

CO7. explore ethical principles and regulatory guidelines governing clinical trials.

Topics and Learning Points

Unit-1 Epidemiology **(7L)**

1.1 Introduction to Epidemiology

1.2 Odds, odds ratio, relative risk.

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

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

Unit-2 Clinical trials **(9L)**

2.1 Introduction to Clinical Trials (CTs): need and ethics of CTs, History of clinical trials, New Drug Application.

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 **(9L)**

3.1 Design of clinical trials: Basic design consideration, introduction, patent selection, selection control parallel and cross-over designs Treatments, 2 periods cross over design.

3.2 Randomization models, Randomization methods.

3.3 Numerical Problems

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

4.1 Bioequivalence and bio-availability, non-inferiority trial

4.2 Practice based medical research, evidence-based medicine

4.3 Numerical Problems

References:

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. Steven Diantadosi (2000) Clinical Trials – A methodological perpective (John Wiley)
6. L.M. Friedmon, C.D. Forbes, D.L. Demats (TT) Fundamentals of Clinics Trials (Spinner)
7. Steve selvin (2000) Epidemiologic Analysis (Oxford)
8. M.M. Shoukni, C.A. Pavse(1999) Statistical Methods for Health Sciences (CPC Pree)
9. Steve Salvin (1999) Statistical Analysis of Epidomiologic Data (Ph. D: Oxford)
10. A. P. Gore, S. A. Paranjpe and M. B. Kulkarni (2010) Lecture Notes on Medical Statistics
11. Taylor, H N and Karlin, S. (1984) An introduction to stochastic modeling(Academic Press)

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2	1	2	2	1	1	1	1	1	1	1	
CO2	2	2	1	2	3	2	1	1	1	2	1	1	3
CO3	3	2	1	3	3	2	1	1	2	1	1	1	
CO4	3	3	1	3	3	2	1	1	2	1	1	3	
CO5	2	3	1	2	3	2	2	2	3	1	2	3	2
CO6	3	3	1	3	3	2	2	2	2	1	2	3	
CO7	2	3	1	2	2	2	3	2	2	2	3	3	3

Justifications for CO-PO Mappings

PO1: Comprehensive Knowledge and Understanding

- Strong relation with CO1, CO3, CO4, CO6 (concepts of epidemiology and clinical trial design).
- Moderate relation with CO2, CO5, CO7 (epidemic events, statistical methods, ethics).

PO2: Practical, Professional, and Procedural Knowledge

- Strong relation with CO4, CO5, CO6, CO7 (application of designs, statistics, conduct, and regulations).
- Moderate relation with CO1–CO3.

PO3: Entrepreneurial Mindset and Knowledge

- Only partially related (CO1–CO7) since entrepreneurial aspects are not central, but awareness of trials, epidemics, and regulations may aid in healthcare innovations.

PO4 : Specialized Skills and Competencies

- Strong relation with CO3, CO4, CO6 (technical and analytical application in clinical trials).
- Moderate with CO1, CO2, CO5, CO7.

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

- Strongly related to CO2 (epidemic detection), CO3, CO4, CO5, CO6 (analysis and application of designs/statistics).
- Moderate to CO1 and CO7.

PO6 : Communication Skills and Collaboration

- Moderately related to CO2, CO3, CO4, CO5, CO6, CO7 (presenting statistical data, teamwork in trials).
- Partially related to CO1.

PO7: Research-related Skills

- Strongly linked with CO7 (ethics, regulatory guidelines).
- Moderate with CO5, CO6 (statistical methods and methodology).
- Partially related with CO1–CO4.

PO8: Learning How to Learn Skills

- Moderately related with CO5–CO7 (learning new tools, adapting to evolving regulatory frameworks).
- Partially related with CO1–CO4.

PO9 : Digital and Technological Skills

- Strongly related with CO5 (statistical methods & ICT tools).
- Moderately with CO3, CO4, CO6, CO7.
- Partially with CO1–CO2.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Moderately linked with CO2 and CO7 (epidemic events affect diverse populations, ethics in trials).
- Partially related with CO1–CO6.

PO11: Value Inculcation and Environmental Awareness

- Strongly related with CO7 (ethics in trials).
- Moderately related with CO5, CO6 (responsible data use, regulations).
- Partially related with others.

PO12: Autonomy, Responsibility, and Accountability

- Strongly linked with CO4, CO5, CO6, CO7 (independent application of designs, ethical responsibility).
- Partially with CO1–CO3.

PO13: Community Engagement and Service

- Strong with CO2, CO7 (epidemics and ethics directly affect communities).
- Moderate with CO5.

CBCS Syllabus as per NEP 2020 for T.Y.B. Sc. Statistics (2023 Pattern)

Name of the Programme : B.Sc. (Statistics)
Program Code : USST
Class : T.Y.B.Sc.
Semester : VI
Course Type : Major Elective (Theory)
Course Code : STA-356-MJE(C)
Course Title : Ecology
No. of Credits : 2 credits
No. of Teaching Hours : 30

Course Objectives:

1. To introduce the fundamental concepts and principles of population dynamics and their applications in ecological and demographic studies.
2. To familiarize students with different population growth models — linear, exponential, logistic, and Gompertz — and their real-world implications.
3. To develop an understanding of age-structured population analysis and the role of demographic parameters in determining population change.
4. To enable students to construct and analyse Leslie matrix models for studying stable and growing populations.
5. To provide knowledge of various statistical approaches for estimating population abundance and density using sampling and distance-based methods.
6. To impart skills for applying capture–recapture and removal methods in estimating population sizes in ecological and experimental settings.
7. To enhance analytical and computational skills for interpreting population models and applying them to data-driven decision-making in biological, environmental, or resource management contexts.

Course Outcomes:

Student will be able to

CO 1. explain the fundamental concepts of population dynamics and their significance in modelling population changes over time.

CO 2. analyse various growth models such as linear, exponential, logistic, and Gompertz curves to understand different types of population growth behaviour.

CO 3. apply age-structured growth analysis and relevant notations to study population changes across generations.

CO 4. construct and interpret Leslie matrix models for age-structured populations, including computation of stable population and growth rate (λ as Perron constant).

CO 5. evaluate the assumptions, advantages, and limitations of Leslie matrix models in real-world population studies.

CO 6. differentiate among Poisson, regular, and aggregated forests, and estimate population density using quadrat sampling and distance-based methods.

CO 7. implement capture–recapture and removal methods for population abundance estimation in ecological and environmental studies.

Topics and Learning Points:

UNIT 1.Population Dynamics: (8L)

1.1 Introduction to Population Dynamics, Why Study Growth Models?

1.2 Growth Analysis w. r. t. age, Notations

1.3 Linear Growth Model, Exponential Model, Logistic Growth Curve, Remarks on Logistic Model, Gomperz Curve, Exercise

UNIT 2.Leslie Matrix Models: (7L)

2.1 Introduction, Notations, Illustration

2.2 Stable Population, Assumptions, Advantages and Disadvantages, λ as a Parron constant, Exercise

UNIT 3. Population Abundance Estimation: (15L)

3.1 Introduction, Poisson Forest, Regular Forest,, Aggregated Forest, Estimation of Population Density (Quadrat Sampling Method, Poisson Forest)

3.2 Density Estimation Using Distance Method (Point to Individual NND, Individual to Individual NND, r^{th} Order Nearest Neighbour Method)

3.3 Capture-Recapture Methods (Procedure of Capture-Recapture Method, Case of Single Recapture, Case of Multiple Recapture)

3.4 Removal Method

3.5 Exercises

References:

1. Berryman, A. A. (2002): Principles of Population Dynamics and Their Application, Stanley Thornes Publishers, Cheltenham.
2. Pielou, E. C. (1977): Mathematical Ecology, Wiley-Interscience Publication, New York.
3. May, R. M. (1976): Simple Mathematical Models with Very Complicated Dynamics, Princeton University Press, Princeton.
4. Lewis, E. G. (1942): On the Generation and Growth of a Population, Sankhyā: The Indian Journal of Statistics, Calcutta.
5. Caswell, H. (2001): Matrix Population Models: Construction, Analysis, and Interpretation, Second Edition, Sinauer Associates, Massachusetts.
6. Seber, G. A. F. (1982): The Estimation of Animal Abundance and Related Parameters, Second Edition, Macmillan Publishers, New York.
7. Krebs, C. J. (1999): Ecological Methodology, Second Edition, Benjamin Cummings Publishers, California.
8. Gotelli, N. J. (2008): A Primer of Ecology, Fourth Edition, Sinauer Associates, Massachusetts.
9. V.K. Kapoor (2016): Problems and Solutions in Biostatistics, Sultan Chand & Sons, New Delhi.

Programme Outcomes and Course Outcomes Mapping:

Course Outcomes	Programme Outcomes (POs)												
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	3	2				1		2		2	2		
CO2	3	3		2	3	1		2	2				
CO3	2	3		2	3	1		2	2			2	
CO4	2	3		3	3	1	3	2	2			2	
CO5	2				3	1	3	2	2			2	
CO6		3	1	2	3	1	2	2	3		2	2	2
CO7		3	2		3	1	3	2	3	2	3	2	3

Justifications for Mapping

PO1: Comprehensive Knowledge and Understanding

- **CO1:** (3) Understanding key concepts of population dynamics and population change models provides a strong theoretical foundation.

- **CO2:** (3) Analyzing linear, exponential, logistic, and Gompertz models deepens conceptual knowledge of population growth theories.
- **CO3:** (2) Applying age-specific growth analysis reinforces understanding of theoretical demographic principles.
- **CO4:** (2) Constructing Leslie matrices enhances conceptual clarity on stable population theory.
- **CO5:** (2) Evaluating model assumptions develops theoretical insight into population behavior.

PO2: Practical, Professional, and Procedural Knowledge

- **CO1:** (2) Application of population models to real-world growth problems fosters professional competence.
- **CO2:** (3) Use of mathematical and computational modeling strengthens procedural knowledge in applied demography.
- **CO3:** (3) Age-structured growth analysis develops data interpretation and modeling skills.
- **CO4:** (3) Building and analyzing Leslie matrices enhances professional skills in matrix population modeling.
- **CO6:** (3) Estimating density using quadrat and distance methods integrates field-based procedural knowledge.
- **CO7:** (3) Capture–recapture and removal methods demonstrate applied research and analytical procedures.

PO3: Entrepreneurial Mind-set and Knowledge

- **CO7:** (2) Applying population estimation methods promotes innovation and resource management awareness.
- **CO6:** (1) Understanding population behavior encourages eco-entrepreneurial and conservation-based thinking.

PO4: Specialized Skills and Competencies

- **CO4:** (3) Constructing and interpreting Leslie matrices requires specialized technical and analytical ability.
- **CO2:** (2) Growth model formulation enhances computational and mathematical competence.
- **CO3:** (2) Age-structured models develop specialized demographic analysis skills.
- **CO6:** (2) Forest-type differentiation builds technical competency in ecological data assessment.

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

- **CO2:** (3) Analytical comparison of growth models fosters mathematical reasoning.
- **CO3:** (3) Applying structured growth models strengthens analytical interpretation.
- **CO4:** (3) Matrix-based computation of stable population and λ builds strong problem-solving ability.
- **CO5:** (3) Evaluating model limitations promotes critical and analytical thinking.
- **CO6:** (3) Population density estimation encourages problem-solving through applied methods.
- **CO7:** (3) Capture–recapture analysis involves critical evaluation and analytical reasoning.

PO6: Communication Skills and Collaboration

- **CO1–CO7:** (1) Students discuss and present results of models and estimation methods through reports and group activities, enhancing scientific communication and teamwork.

PO7: Research-related Skills

- **CO4:** (3) Leslie model analysis provides a foundation for population-based research and data modelling.
- **CO5:** (3) Evaluation of model assumptions promotes research inquiry and interpretation.
- **CO6:** (2) Forest-type analysis involves hypothesis-based investigation and data collection.
- **CO7:** (3) Capture–recapture techniques reinforce experimental design and research ethics.

PO8: Learning How to Learn Skills

- **CO1–CO7:** (2) Continuous learning through model development and application helps students adapt to new analytical and computational methods.

PO9: Digital and Technological Skills

- **CO6:** (3) Applying computational tools for distance and quadrat methods builds digital proficiency.
- **CO7:** (3) Capture–recapture simulations enhance data-handling and software-based analysis skills.
- **CO2–CO5:** (2) Modelling population data improves use of statistical and computational technologies.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO1:** (2) Understanding human population trends develops empathy and awareness of societal diversity.
- **CO7:** (2) Ecological population studies encourage inclusivity and respect for biodiversity.

PO11: Value Inculcation and Environmental Awareness

- **CO1:** (2) Population studies foster awareness of ecological balance and sustainability.
- **CO6:** (2) Understanding forest population types promotes environmental conservation.
- **CO7:** (3) Capture–recapture methods relate directly to wildlife and ecological preservation ethics.

PO12: Autonomy, Responsibility, and Accountability

- **CO3–CO7:** (2) Students take initiative in performing modelling, analysis, and reporting tasks responsibly.

PO13: Community Engagement and Service

- **CO6:** (2) Estimation of forest population density encourages community-based resource management.
- **CO7: (3)** Applying population estimation in environmental studies supports conservation and community engagement.

CBCS Syllabus as per NEP 2020 for T.Y.B. Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Program Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** VI
Course Type	**:** Minor (theory)
Course Code	**:** STA-361-MN
Course Title	**:** Statistical Techniques – II
No. of Credits	**:** 2 credits
No. of Teaching Hours	**:** 30

Course Objectives:

1. To introduce regression techniques for predictive analysis.
2. To understand the concept and importance of multiple linear regression models for analyzing multivariate data.
3. To understand the concept, formulation, and applications of logistic regression models for categorical response variables.
4. To develop understanding of time series analysis and forecasting methods.
5. To familiarize students with simulation techniques for complex problem-solving.
6. To apply Statistical Process Control (SPC) methods for quality improvement and
7. monitoring.
8. To equip students with analytical tools for real-world data interpretation and decision-making.

Course Outcomes:

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

CO 1. Explain the basic concepts and assumptions of multiple linear regression, time series, simulation, and SPC techniques.

CO 2. Compute and interpret regression coefficients for multivariate data.

CO 3. Fit appropriate regression models and evaluate their adequacy using coefficient of determination (R^2) and residual analysis.

CO 4. Identify components of time series data (trend, seasonal, cyclical, and irregular) and apply methods for trend and seasonal estimation.

CO 5. Apply simulation techniques such as Monte Carlo methods for solving probabilistic,

inventory, and queuing problems.

CO 6. Construct and interpret various control charts ($\bar{X}$, R, p, np, c) for process monitoring and quality improvement.

CO 7. Integrate statistical techniques to analyze real-life data and communicate inferences effectively for decision-making.

Topics and Learning Points

UNIT 1: Time Series Analysis (10L)

1.1. Introduction, Meaning and utility of time series, Definition, Components of Time Series: i) The Trend ii) Seasonal variation iii) Cyclical variation iv) Irregular variation, Additive and Multiplicative Model

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

1.3. Choosing parameters for smoothing and forecasting.

1.4. Forecasting based on exponential smoothing.

1.5. Measurement of seasonal variations: i) simple average method, ii) ratio to moving average method.

1.6. Fitting of autoregressive model

UNIT2: Simulation (5 L)

2.1 Concept and need of simulation

2.2 Steps in simulation study

2.3 Random number generation (uniform & normal distributions)

2.4 Monte Carlo simulation

2.5 Applications in: Probability estimation, Chemical process variability, Inventory or queuing problems.

2.6 Use of software (Excel/R) for simple simulations

Unit 3: Statistical Process Control (SPC) (7 L)

3.1 Concept of process variation and quality improvement

3.2 Types of variation: chance and assignable causes

3.3 Control charts for variables: $\bar{X}$ chart and R-chart

3.4 Control charts for attributes: p, np, c, and u charts

3.5 Process capability indices: C_p, C_{pk}

3.6 Industrial and laboratory applications

UNIT-4: Multiple Linear and Logistic Regression Analysis (8 L)

4.1 Concept of multiple linear regression (tri-variate data only)

4.2 Coefficient of determination (R^2) and adjusted coefficient of determination and interpretation

4.3 Concept of logistic regression analysis.

4.4 Concept of odds and log odds

4.5 Applications of logistic regression in real life

References:

1. Gupta, S. C., & Kapoor, V. K. – Fundamentals of Applied Statistics.
2. Montgomery, D. C. – Introduction to Statistical Quality Control.
3. Bowerman, O'Connell & Koehler – Forecasting, Time Series, and Regression.
4. Ross, S. M. – Simulation and Monte Carlo Methods.
5. Spiegel, M. R. – Schaum's Outline: Theory and Problems of Statistics

Programme Outcomes and Course Outcomes Mapping:

COs\ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2	1	1	2	2	1	2	1	1	1	1	1	1
CO2	2	3	2	3	3	1	2	1	2	1	1	2	1
CO3	2	3	1	3	3	1	2	1	2	1	1	2	1
CO4	2	3	1	3	3	1	2	1	2	1	1	2	1
CO5	2	3	1	3	3	1	2	1	2	1	1	2	1
CO6	2	3	2	3	3	1	2	1	2	1	1	2	1
CO7	2	3	2	3	3	1	2	1	2	1	1	2	1

Justification for Mapping PO and CO

PO1: Comprehensive Knowledge and Understanding

- CO1: Understanding and applying regression reflects strong foundational statistical knowledge. (3)
- CO2: Applying time series models for forecasting uses core statistical theory and concepts. (3)
- CO3: Understanding random numbers and simulation demonstrates sound conceptual grasp of probability models. (2)

- CO4: Implementing Monte Carlo simulation integrates theoretical and applied knowledge of randomness. (2)
- CO5: Applying SQC techniques shows fundamental understanding of process variation and control theory. (2)
- CO6: Computing process capability indices reflects conceptual clarity in quality metrics. (2)
- CO7: Using statistical software to analyze data reinforces theoretical knowledge through practical application. (3)

PO2: Practical, Professional, and Procedural Knowledge

- CO1: Applying regression for prediction cultivates professional analytical skills. (2)
- CO2: Conducting time series forecasting reflects industry-oriented analytical ability. (3)
- CO3: Using simulation methods represents procedural competency in experimentation. (2)
- CO4: Implementing Monte Carlo techniques fosters professional modeling experience. (3)
- CO5: Using control charts demonstrates applied professional practice in process industries. (3)
- CO6: Evaluating process capability shows practical understanding of industrial standards. (3)
- CO7: Employing statistical software builds procedural skill relevant to workplace analysis. (3)

PO3: Entrepreneurial Mindset and Knowledge

- CO1: Regression-based decision making supports business and entrepreneurial analytics. (2)
- CO2: Forecasting trends promotes entrepreneurial planning and market analysis. (3)
- CO3: Simulation modeling enhances innovative and risk-assessment thinking. (2)

- CO4: Monte Carlo techniques assist in financial and production decision scenarios. (3)
- CO5: SQC application helps in quality management and productivity enhancement. (3)
- CO6: Process capability analysis supports managerial process improvement. (3)
- CO7: Use of data tools aids in data-driven entrepreneurial insights. (2)

PO4: Specialized Skills and Competencies

- CO1: Builds competency in statistical relationship analysis. (2)
- CO2: Strengthens forecasting specialization and analytical expertise. (3)
- CO3: Develops specialized skills in simulation design. (2)
- CO4: Enhances computational proficiency in stochastic modeling. (3)
- CO5: Cultivates quality control skills applicable in industry. (3)
- CO6: Strengthens technical competency in process evaluation. (3)
- CO7: Builds specialized data-handling and reporting skills. (3)

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

- CO1: Regression interpretation develops analytical reasoning. (3)
- CO2: Time series modelling enhances critical analysis of temporal data. (3)
- CO3: Simulation application encourages logical problem-solving. (2)
- CO4: Monte Carlo method promotes reasoning under uncertainty. (3)
- CO5: SQC interpretation improves diagnostic reasoning. (3)
- CO6: Process capability indices strengthen data-driven judgment. (3)
- CO7: Software-based analysis fosters applied problem-solving skills. (3)

PO6: Communication Skills and Collaboration

- CO1: Interpreting regression output improves statistical communication. (2)
- CO2: Presenting forecasting results develops data storytelling ability. (2)
- CO3: Documenting simulation results encourages collaborative learning. (1)
- CO4: Reporting Monte Carlo outcomes enhances clarity and precision. (1)
- CO5: Presenting control charts encourages team-based quality review. (2)

- CO6: Communicating process capability analysis promotes professional discussion. (2)
- CO7: Writing software-based reports enhances technical communication skills. (3)

PO7: Research-related Skills

- CO1: Regression analysis forms a foundation for applied research. (2)
- CO2: Time series forecasting supports data-driven research design. (3)
- CO3: Simulation fosters experimental and analytical thinking. (2)
- CO4: Monte Carlo techniques contribute to computational research. (3)
- CO5: Quality control charts provide research-based insights in process improvement. (2)
- CO6: Process capability analysis encourages data-based research conclusions. (2)
- CO7: Using software enhances research data handling and visualization. (3)

PO8: Learning How to Learn Skills

- CO1: Applying regression develops continuous analytical learning. (1)
- CO2: Forecasting through time series encourages adaptive learning. (2)
- CO3: Simulation techniques promote independent problem exploration. (3)
- CO4: Monte Carlo experimentation nurtures self-directed learning. (3)
- CO5: Applying SQC methods develops iterative learning from processes. (2)
- CO6: Capability study enhances reflective and lifelong learning. (2)
- CO7: Software practice sustains ongoing skill development. (3)

PO9: Digital and Technological Skills

- CO1: Regression computations via software strengthen digital analysis. (2)
- CO2: Time series forecasting enhances software proficiency. (3)
- CO3: Simulation improves computational literacy. (3)
- CO4: Monte Carlo programming promotes digital problem-solving. (3)
- CO5: Quality control through Excel or R encourages digital competency. (2)
- CO6: Process capability computation enhances data analytics skills. (3)
- CO7: Statistical software use directly develops digital expertise. (3)

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- CO1: Regression examples from social sciences foster inclusiveness. (1)
- CO2: Time series analysis of socio-economic data builds multicultural awareness. (2)
- CO3: Simulation of real-life social models enhances empathy. (1)
- CO4: Monte Carlo studies of community issues promote inclusivity. (1)
- CO5: Quality control applied to social services demonstrates empathy-driven application. (1)
- CO6: Process evaluation supports equitable and inclusive quality outcomes. (1)
- CO7: Data projects from diverse sectors encourage social understanding. (2)

PO11: Value Inculcation and Environmental Awareness

- CO1: Ethical regression reporting supports academic integrity. (1)
- CO2: Responsible forecasting promotes sustainable decisions. (1)
- CO3: Simulation modelling emphasizes ethical data use. (1)
- CO4: Monte Carlo methods apply to environmental risk studies. (1)
- CO5: Quality control promotes sustainable resource management. (2)
- CO6: Capability indices highlight responsible production practices. (2)
- CO7: Software analysis encourages ethical digital conduct. (1)

PO12: Autonomy, Responsibility, and Accountability

- CO1: Independent regression projects build accountability. (2)
- CO2: Forecasting tasks require autonomous interpretation. (2)
- CO3: Designing simulations fosters responsibility in experimentation. (2)
- CO4: Monte Carlo projects enhance ownership of learning. (2)
- CO5: SQC activities encourage professional accountability. (3)
- CO6: Capability analysis develops responsible decision-making. (3)
- CO7: Software-based data analysis builds independent working ability. (3)

PO13: Community Engagement and Service

- CO1: Regression on social data builds community relevance. (1)

- CO2: Forecasting social indicators promotes civic awareness. (2)
- CO3: Simulation of public systems aids policy improvement. (1)
- CO4: Monte Carlo studies applied to healthcare or environment enhance service learning. (1)
- CO5: SQC in public sectors contributes to community quality. (2)
- CO6: Capability studies in civic systems promote service effectiveness. (2)
- CO7: Data reporting for societal studies enhances public engagement. (2)

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2023 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc
Semester	**:** VI
Course Type	**:** Minor (Practical)
Course Code	**:** STA-362-MN
Course Title	**:** Minor Statistics Practical – IV
No. of Credits	**:** 02
No. of Teaching Hours	**:** 60

Course Objectives:

1. To develop the ability to estimate and forecast future values using curve fitting and least squares principles for various real-life data sets.
2. To understand and apply time series techniques such as moving averages, exponential smoothing, and autoregressive (AR) models for identifying and predicting trends.
3. To analyze seasonal variations and estimate seasonal indices using the ratio-to-trend method for improving forecasting accuracy.
4. To develop proficiency in fitting multiple and logistic regression models using R software for analyzing and predicting relationships between multiple variables.
5. To construct and interpret control charts (both variable and attribute types) for monitoring process stability and quality control in industrial and business applications.
6. To apply simulation techniques and conduct case studies for practical understanding of statistical modeling and decision-making in uncertain environments.
7. To evaluate process performance through process capability analysis for normally distributed data and assess process improvement opportunities.

Course Outcomes:

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

CO1. apply the method of least squares to fit different types of curves and forecast values based on the estimated models.

CO2. analyze and estimate trends in time series data using moving average, exponential smoothing, and autoregressive methods.

CO3. evaluate and interpret seasonal variations by computing seasonal indices using the ratio-to- trend approach.

CO4. fit and interpret simple and multiple linear regression models using Excel and R software to establish relationships among variables.

CO5. compute and interpret multiple correlation coefficients to understand interdependence among several variables.

CO6. construct and interpret variable and attribute control charts ($\bar{X}$-chart, R-chart, p-chart, c-chart) for quality control and process monitoring.

CO7. apply statistical simulation techniques and case study analysis for real-world problem solving and decision-making.

Topics and Learning Points

Sr. No.	Title of Experiments
1	Estimation and Forecasting by Curve Fitting Using Least Square Principle **(by using MS-EXCEL)**
2	Time Series- Estimation of trend by using the method of moving averages. **(by using MS-EXCEL)**
3	Estimation and Forecasting of Trend by Exponential Smoothing, AR(1) model. **(by using MS-EXCEL)**
4	Estimation of Seasonal Indices By Ratio to Trend. (equivalent to 2 practicals) **(by using MS-EXCEL)**
5	Fitting Multiple linear regression (by using R-Software)
6	Logistic Regression (by using R-Software)
7	Construction of Variable Control Charts ($\bar{X}$-chart and R-chart)
8	Construction of Attribute Control Charts (p-chart and c-chart)
9	Simulations (by using MS-EXCEL)
10	Process capability Analysis for Normal data.
11	Case Study (Equivalent to 4 practical)

Programme Outcomes and Course Outcomes Mapping:

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PO13
CO1	2	1	1	2	2	1	2	1	1	1	1	1	1
CO2	2	3	2	3	3	1	2	1	2	1	1	2	1
CO3	2	3	1	3	3	1	2	1	2	1	1	2	1
CO4	2	3	1	3	3	1	2	1	2	1	1	2	1
CO5	2	3	1	3	3	1	2	1	2	1	1	2	1
CO6	2	3	2	3	3	1	2	1	2	1	1	2	1
CO7	2	3	2	3	3	1	2	1	2	1	1	2	1

Justifications

PO1: Comprehensive Knowledge and Understanding

- CO1: Understanding and applying regression reflects strong foundational statistical knowledge. (3)
- CO2: Applying time series models for forecasting uses core statistical theory and concepts. (3)
- CO3: Understanding random numbers and simulation demonstrates sound conceptual grasp of probability models. (2)
- CO4: Implementing Monte Carlo simulation integrates theoretical and applied knowledge of randomness. (2)
- CO5: Applying SQC techniques shows fundamental understanding of process variation and control theory. (2)
- CO6: Computing process capability indices reflects conceptual clarity in quality metrics. (2)
- CO7: Using statistical software to analyze data reinforces theoretical knowledge through practical application. (3)

PO2: Practical, Professional, and Procedural Knowledge

- CO1: Applying regression for prediction cultivates professional analytical skills. (2)
- CO2: Conducting time series forecasting reflects industry-oriented analytical ability. (3)

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