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 -V

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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19.	**Prof. Gardi Chandrakant Gopal**	Subject Expert from Outside the Parent University
20.	**Mr. Kadam Saurabh**	Representative from industry/corporate sector/allied areas
21.	**Dr. Limbore Jaya Laxman**	Member of the College Alumni
22.	**Miss. Shirke Satakshi Shrikant**	UG Student
23.	**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 Inference – 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 Inference – 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	: V
Course Type	: Major Mandatory (Theory)
Course Code	: STA-301-MJM
Course Title	: Distribution Theory – I
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 learn general strategies for problems about order statistics and applications of order statistics.
6. To investigate applications of the Weibull distribution in analysing failure rates, lifetime data, and time-to-event data.
7. To understand the concept of order statistics and their role in statistical inference.

Course Outcome:

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

CO1. Develop problem solving techniques needed to calculate probabilities.

CO2. Understand the most common continuous probability distributions and their real-life applications.

CO3. Understanding of distribution helps to understand the nature of data and to perform appropriate analysis.

CO4. The paper shall expose the students to different aspects of distribution theory. On studying this paper students can get to learn the theory

underlying the construction of these distributions.

CO5. Thoroughly understanding the procedures of probability distributions students can apply these distributions to model random events.

CO6. On studying the theory of order statistics students can learn how to model product failure, droughts, floods and other extreme occurrences.

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

Topics and Learning Points

Unit - 1. Beta Distribution **(10 L)**

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

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

$$= 0 \quad ;\ \text{Otherwise}$$

Notation: $X \sim \beta_{1(m,n)}$.

Nature of probability curve, Derivation of mean, variance, r^{th} raw moment, harmonic mean, mode, symmetry of the distribution.

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

1.3 Beta distribution of second kind: p.d.f.

$$f(x) = \frac{1}{\beta(m,n)} \frac{x^{m-1}}{1-x^{m+n}}\ ;\ x \ge 0,\ m,\ n>0$$

$$= 0 \quad ;\ \text{Otherwise}$$

Notation: $X \sim \beta_2(m,n)$.

Nature of probability curve, Derivation of mean, variance, r^{th} raw moment, harmonic mean, mode, symmetry of the distribution.

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

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

1.6 Statement of relation between distribution function of and binomial distribution.

1.7 Illustrative examples.

Unit - 2. Weibull Distribution **(6 L)**

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

$= 0$ $; elsewhere$

Notation : X~ W(α , β).

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

2.3 Real life situations and applications.

Unit – 3 Order Statistics **(8 L)**

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

3.2. Distribution of $X_{(i)}$ for random sample from uniform and exponential distributions.

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

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

3.5. Distribution of sample range

3.6. Illustrative examples.

Unit – 4 Cauchy Distribution **(6 L)**

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

$= 0$ $; elsewhere$

Notation: X ~ C (μ, λ)

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

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

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

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

4.6 Illustrative examples.

References:

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

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	2	3	1	2	3	1	2	2	1	-	-	2	-
CO2	3	2	-	2	2	-	2	1	-	-	-	1	-
CO3	2	3	-	2	3	1	3	2	2	-	-	2	-
CO4	3	2	-	2	2	-	2	1	-	-	-	1	-
CO5	2	2	-	3	2	-	3	2	1	-	-	2	-
CO6	2	3	1	3	3	1	3	2	2	-	-	2	1
CO7	2	2	-	3	2	1	3	2	1	-	-	1	-

PO1: Comprehensive Knowledge and Understanding

- CO2 and CO4:1 - emphasize theoretical grounding and statistical theory fundamentals.
- CO1 and CO3: 3 - involve the application of theoretical knowledge.

PO2: Practical, Professional, and Procedural Knowledge

- CO1, CO3, and CO6: 1 - these outcomes involve applying statistical distributions and tools to real-world problems.
- CO7 : 3- emphasizes the application of order statistics in inference.

PO3: Entrepreneurial Mindset and Knowledge

- CO6 : 2- Weibull distribution analysis can support decision-making in entrepreneurial contexts.

PO4: Specialized Skills and Competencies

- CO5, CO6, and CO7 : 1 - to their focus on analytical reasoning and specialized statistical applications.

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

- CO1, CO3, and CO6 : 1 - they develop skills for solving statistical problems and analyzing data.

PO6: Communication Skills and Collaboration

- CO3, CO6, and CO7 : 2- where reporting and explaining statistical results might involve effective communication.

PO7: Research-related Skills

- CO3, CO5, CO6, and CO7 : 1 - focus on inquiry and statistical analysis methodologies.

PO8: Learning How to Learn Skills

- CO1, CO3, and CO5 : 3 - these develop adaptability and self-learning in statistical problem-solving.

PO9: Digital and Technological Skills

- CO3 and CO6 : 3 - these involve using statistical software for analysis.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Not directly related to any CO.

PO11: Value Inculcation and Environmental Awareness

- Not directly related to any CO.

PO12: Autonomy, Responsibility, and Accountability

- CO1, CO3, and CO6 : 3- they require independent problem-solving and accountability in statistical work.

PO13: Community Engagement and Service

- CO6 : 2 - as statistical methods like the Weibull distribution can contribute to community-related studies.

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	: V
Course Type	: Major Mandatory (Theory)
Course Code	: STA-302-MJM
Course Title	: Theory of Estimation
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

The main objective of this course is to get knowledge about

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

Course Outcomes:

After completing this course, students will possess skills concerning:

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

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

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

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

CO 5. Characteristics of a good estimator

CO 6. Different methods of estimation

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

Topics and Learning Points

Unit 1: Methods of Estimation **(8 L)**

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

1.2 Method of Maximum Likelihood:

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

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

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

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

1.2.5 M.L.E. of location parameter in Laplace distribution.

1.2.6 Invariance property of M.L.E.

Unit 2: Properties of Estimators

2.1 Unbiasedness **(4 L)**

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

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

(b) If T is an unbiased estimator of θ, then $\phi(T)$ is unbiased estimator of $\phi(\theta)$ provided $\phi(.)$ is a linear function.

2.2 Efficiency **(3 L)**

Relative efficiency of unbiased estimator T_1 with respect to another unbiased estimator T_2, use of mean square error to define relative efficiency of biased estimators, Notion of the Best Linear Unbiased Estimator and Uniformly Minimum Variance Unbiased Estimator (UMVUE), uniqueness of UMVUE whenever it exists, Examples and problems.

2.3 Sufficiency **(6 L)**

Concept and definition of sufficiency, statement of the Fisher-Neyman factorization

theorem with proof for discrete probability distribution. Pitmann – Koopman form and sufficient statistic; Exponential family of probability distributions and sufficient statistic. Examples and problems. Proofs of the following properties of sufficient statistics:

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

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

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

Unit 3: Asymptotic Behaviour of an Estimator **(4 L)**

3.1. Chebychev's inequality for discrete and continuous distributions. Consistency: Definition.

3.2. Proof of the following theorems:

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

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

3.3. Examples and problems.

Unit 4: Cramer- Rao Inequality **(5 L)**

4.1 Fisher information function: Amount of information contained in statistic. Statement regarding information in sample and in a sufficient statistic T.

4.2 Cramer- Rao Inequality

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

4.2.2. Proofs of following results:

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

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

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

4.2.4. Efficiency of unbiased estimator T w. r. t. CRLB.

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13. Dixit, U. J. (2016) Examples in Parametric Inference with R. Singapore: Springer.
14. Fergusson T. S. (1996) Mathematical Statistics.

Programme Outcomes and Course Outcomes Mapping:

PO	PO.1	PO.2	PO.3	PO.4	PO.5	PO.6	PO.7	PO.8	PO.9	PO.10	PO.11	PO.12	PO.13
CO 1	3	2	1	2	3	1	2	2	2	1	1	2	1
CO 2	3	2	1	2	3	1	2	2	2	1	1	2	1
CO 3	3	2	1	3	3	2	3	2	2	1	1	2	1
CO 4	3	2	1	3	3	2	3	2	2	1	1	2	1
CO 5	3	2	1	3	3	2	3	2	2	1	1	2	1
CO 6	3	2	1	3	3	2	3	2	2	1	1	2	1
CO 7	3	2	1	3	3	2	3	2	2	1	1	2	1

Justification of CO-PO Mapping

PO1: Comprehensive Knowledge and Understanding (Strongly Related - 3)

All COs (CO1 to CO7) contribute significantly to PO1 as they develop foundational knowledge of estimation methods, statistical concepts, and mathematical reasoning.

PO2: Practical, Professional, and Procedural Knowledge (Moderately Related - 2)

The course covers practical aspects of estimation and its real-world applications, making it moderately related to PO2.

PO3: Entrepreneurial Mindset and Knowledge (Partially Related - 1)

Although estimation methods are used in data-driven decision-making, their direct link to entrepreneurship is limited.

PO4: Specialized Skills and Competencies (Strongly Related - 3)

The course builds statistical analysis skills, improving technical proficiency, analytical reasoning, and problem-solving, making it strongly related to PO4.

PO5: Capacity for Application, Problem-Solving, and Analytical Reasoning (Strongly Related - 3)

All COs align with PO5 as estimation methods require critical thinking, analytical reasoning, and problem-solving in real-world contexts.

PO6: Communication Skills and Collaboration (Partially Related - 1)

While statistics requires clear communication of findings, this course does not explicitly focus on collaboration, making it only partially related.

PO7: Research-related Skills (Moderately to Strongly Related - 2/3)

Since estimation is a fundamental aspect of statistical research, COs are moderately to strongly related to PO7.

PO8: Learning How to Learn Skills (Moderately Related - 2)

Understanding estimation methods enhances self-learning capabilities by fostering adaptability and independent thinking.

PO9: Digital and Technological Skills (Moderately Related - 2)

Although estimation is mathematical, its application often involves statistical software, making it moderately related to PO9.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy (Partially Related - 1)

Statistics is universal, but estimation methods have minimal direct links to multicultural competence.

PO11: Value Inculcation and Environmental Awareness (Partially Related - 1)

While ethical use of statistics is important, estimation methods have limited direct impact on ethical values or environmental concerns.

PO12: Autonomy, Responsibility, and Accountability (Moderately Related - 2)

Students apply statistical knowledge independently and are responsible for ensuring accurate estimations, making this moderately related.

PO13: Community Engagement and Service (Partially Related - 1)

While statistical knowledge can support community research, estimation techniques themselves have limited direct community engagement applications.

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	: V
Course Type	: Major Mandatory (Theory)
Course Code	: STA-303-MJM
Course Title	: Sampling Methods
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

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

Course Outcome:

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

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

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

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

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

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

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

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

Topics and Learning Points

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

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

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

(b) $N\bar{y}$ as an estimator of population total, derivation of expectation and standard error of $N\bar{y}$

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

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

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

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

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

1.4 Determination of Sample Size (in case of SRS) for the given

(a) Margin of error and confidence coefficient.

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

Unit-2. Stratified Random Sampling **(8 L)**

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

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

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

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

(c) Estimator of above standard errors.

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

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

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

Unit-3. Ratio and Regression Methods of Estimation for SRSWOR (Sampling Methods using Auxiliary variables) (4 L)

3.1. Rationale behind using auxiliary variates in estimation.

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

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

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

Unit-4. Systematic Sampling (Linear Systematic Sampling) (5 L)

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

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

4.3 Comparison of systematic sampling with SRSWOR.

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

Unit-5. Role of Sample Surveys in Research Methodology (3 L)

5.1. Objectives of a sample survey.

5.2. Designing a questionnaire, characteristics of a good questionnaire (Questions with codes & scores are to be discussed). Reliability and validity testing by using Internal Consistency: (i) Kuder Rechardson Coefficient (KR-20), (ii) Cronbach's Coefficient Alpha

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

5.4. Sampling and non-sampling errors with illustrations.

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

Unit-6. Non-probability sampling techniques **(2 L)**

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

References:

1. Cochran, W. G. (1977) Sampling Techniques, third Edition Wiley Eastern Ltd., New Delhi.
2. Malhotra N. (2008) Marketing Research and Applied Orientation (third edition), Prentice Hall of India.
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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			3	3								
CO2	3					2	3						2
CO3		3		3					2				
CO4		3			3	2	3	3				2	
CO5	3										2		
CO6			2		3		3	3		2		2	2
CO7		3	2	3					2				

PO1: Comprehensive Knowledge and Understanding

CO1 (3): Understanding different sampling designs requires foundational knowledge of probability and statistics.

CO2 (3): Concepts of population estimation and statistical inference are core to comprehensive knowledge.

CO5 (3): Understanding sampling error aligns with theoretical knowledge of statistics and its implications.

PO2: Practical, Professional, and Procedural Knowledge

CO3 (3): Determining sample size is a practical skill essential in professional statistical analysis.

CO4 (3): Practical issues in sampling are crucial for applying statistical techniques effectively.

CO7 (3): Implementing systematic sampling requires applied knowledge and practice.

PO3: Entrepreneurial Mindset and Knowledge

CO6 (2): Understanding non-probability sampling is useful in market research and business analytics.

CO7 (2): Systematic sampling is commonly used in industry applications, aiding business decision-making.

PO4: Specialized Skills and Competencies

CO1 (3): Identifying appropriate sampling techniques is a specialized statistical skill.

CO3 (3): Estimating sample sizes requires analytical reasoning and decision-making skills.

CO7 (3): Implementing systematic sampling is a technical competency in data science and analytics.

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

CO1 (3): Choosing the correct sampling design requires analytical thinking.

CO4 (3): Addressing practical sampling issues strengthens problem-solving ability.

CO6 (3): Recognizing biases in non-probability sampling develops critical analysis skills.

PO6: Communication Skills and Collaboration

CO2 (2): Explaining sampling estimates requires clear communication of statistical results.

CO4 (2): Discussing practical sampling issues involves teamwork and data presentation.

PO7: Research-related Skills

CO2 (3): Estimating population parameters is fundamental to research methodology.

CO4 (3): Understanding practical challenges enhances research design capabilities.

CO6 (3): Recognizing biases in non-probability sampling is crucial for research validity.

PO8: Learning How to Learn Skills

CO4 (3): Appreciating sampling complexities promotes independent learning.

CO6 (3): Studying biases in non-probability sampling encourages continuous research engagement.

PO9: Digital and Technological Skills

CO3 (2): Computing sample sizes often involves statistical software.

CO7 (2): Implementing systematic sampling may require technology-based approaches.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

CO6 (2): Understanding biases in sampling fosters inclusivity in research.

PO11: Value Inculcation and Environmental Awareness

CO5 (2): Understanding sampling error helps in making ethical and responsible statistical interpretations.

PO12: Autonomy, Responsibility, and Accountability

CO4 (2): Addressing practical issues requires accountability in data collection.

CO6 (2): Recognizing biases emphasizes responsibility in research methodology.

PO13: Community Engagement and Service

CO2 (2): Sampling methods are useful in community-based research.

CO6 (2): Understanding non-probability sampling helps in designing surveys for public welfare 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	: V
Course Type	: Major Mandatory (Theory)
Course Code	: STA-304-MJM
Course Title	: Design of Experiments
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

1. To introduce the fundamental concepts and principles of Design of Experiments (DOE).
2. To Understand the fundamental principles and objectives of experimental design.
3. To develop an understanding of the basic terms and principles such as randomization, replication, and local control.
4. To explain different standard experimental designs, including CRD, RBD, and LSD, along with their statistical analysis.
5. To introduce linear treatment contrasts, orthogonal contrasts, and multiple comparison procedures.
6. Learn how to design and analyze factorial experiments with two or more factors.
7. Students should be able to identify the design, carryout various experiments and analyse the data.

Course Outcomes:

CO.1 Students will be able to define and explain the key concepts and principles of DOE.

CO.2 Students will be able to apply randomization, replication, and local control in designing experiments.

CO.3 Students will be able to design and analyze experiments using CRD, RBD, and LSD.

CO.4 Students should be able to analyze the data of various experimental design.

CO.5 Learn the concept of factorial experiments and understand how to design and analyze experiments with multiple factors.

CO.6 Learn about confounding in experimental designs.

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

Topics and Learning Points

Unit-1 Introduction **(4 L)**

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

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

1.4 Choice of size and shape of a plot.

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

1.6 Overview of General linear model.

Unit-2 Standard Designs of Experiments **(10 L)**

2.1 **Completely Randomized Design (CRD):** Application of the principles of design of experiment in CRD, Layout of CRD, Model: $X_{ij} = \mu + \alpha_i + \varepsilon_{ij}$ i = 1, 2, …, t; j = 1, 2, …., n_i assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of (ANOVA) table, testing equality of treatment effects, Hypothesis to be tested $H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_t = 0$. F test (without derivation). test for equality of two specified treatment effects using critical difference (C.D). Merits and demerits of CRD.

2.2 **Randomized Block Design (RBD):** Application of the principles of design of experiments in RBD, layout of RBD, Model: $X_{ij} = \mu + \alpha_i + \beta_j + \varepsilon_{ij}$ i = 1, 2, …, t; j = 1, 2, …, b, Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares, components of variance, preparation of analysis of variance table, Hypotheses to be tested H_{01}: $\alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_t = 0$; $H_{02} : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_b = 0$. F test (without derivation), test for equality of two specified treatment effects using critical difference (CD). Merits and demerits of RBD.

2.3 **Latin Square Design (LSD):** Application of the principles of design of experiments in LSD, layout of LSD, Model: $X_{ijk} = \mu + \alpha_i + \beta_j + \gamma_k + \varepsilon_{ijk}$ i = 1, 2,⋯, m; j = 1, 2, ⋯, m; k = 1, 2, ⋯, m. Assumptions and interpretations. Breakup of total sum of squares into components. Estimation of parameters, expected values of mean sums of squares,

components of variance, preparation of analysis of variance table, hypotheses to be tested. H_{01}: $\alpha_1 = \alpha_2 = \alpha_3 = \ldots = \alpha_m = 0$; H_{02}: $\beta_1 = \beta_2 = \beta_3 = \ldots = \beta_m = 0$; H_{03} : $\gamma_1 = \gamma_2 = \cdots = \gamma_m = 0$ and their interpretation. F test (without derivation). Preparation of ANOVA table and F test for H_{01}, H_{02} and H_{03} testing for equality of two specified treatment effects, comparison of treatment effects using critical difference, linear treatment contrast and testing its significance. Merits and demerits of LSD.

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

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

Unit-3 Analysis of non- normal data using **(4 L)**

3.1 Square root transformation for counts.

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

3.3 Kruskal Wallis test.

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

4.1 Concept and definition of efficiency of a design.

4.2 Efficiency of RBD over CRD.

4.3 Efficiency LSD over CRD.

4.4 Efficiency LSD over RBD taking

i) Row as a Block.

ii) Column as a Block.

4.5 Simple numerical problems.

Unit-5 Factorial Experiments **(8 L)**

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

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

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

5.4 General idea of confounding in factorial experiments.

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

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

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

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

References:

1. Cochran W. G. and Cox, C. M. (1968) Experimental Design, John Wiley and Sons, Inc., New York.
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10. Wu, C. F. J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc., Hoboken, New Jersey.

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	1	-	-	-	-	-	3	-	-	-	-	-
CO2	-	3	-	-	3	-	-	-	-	1	-	-	-
CO3	-	3	-	3	-	2	-	-	-	-	-	2	-
CO4	-	3	-	3	3	2	3	-	3	-	-	-	-
CO5	3	-	2	-	3	-	-	3	-	-	-	-	1
CO6	2	-	-	-	-	-	3	-	-	-	-	-	-
CO7	-	-	2	2	3	-	3	-	-	-	2	-	-

Justification:

PO1: Comprehensive Knowledge and Understanding

CO1 (3): Strongly related as students gain a deep understanding of the key principles and concepts of DOE.

CO5 (3): Strongly related as factorial experiments involve advanced theoretical knowledge.

CO6 (2): Moderately related, as confounding requires a conceptual understanding of design principles.

PO2: Practical, Professional, and Procedural Knowledge

CO2 (3): Strongly related as students apply randomization, replication, and local control in practical experiment design.

CO3 (3): Strongly related as designing CRD, RBD, and LSD requires procedural knowledge.

CO4 (3): Strongly related since analyzing experimental data requires procedural skills.

PO3: Entrepreneurial Mindset and Knowledge

CO5 (2): Moderately related, as factorial experiments help in optimizing product development and innovation.

CO7 (2): Moderately related, as efficiency concepts can support cost-effective decision-making in businesses.

PO4: Specialized Skills and Competencies

CO3 (3): Strongly related as students acquire specialized skills in designing experiments.

CO4 (3): Strongly related as data analysis in DOE requires domain-specific competencies.

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

CO2 (3): Strongly related since applying DOE principles involves problem-solving.

CO4 (3): Strongly related as analyzing experimental data involves reasoning and statistical interpretation.

CO7 (3): Strongly related as efficiency evaluation requires strong analytical skills.

PO6: Communication Skills and Collaboration

CO3 (2): Moderately related, as designing experiments often requires teamwork and discussion.

CO4 (2): Moderately related, since presenting and interpreting data requires clear communication.

PO7: Research-related Skills

CO4 (3): Strongly related, as data analysis is a core research skill.

CO6 (3): Strongly related, since confounding effects are crucial in experimental research.

PO8: Learning How to Learn Skills

CO1 (3): Strongly related, as DOE concepts require continuous learning and adaptation.

CO5 (3): Strongly related, as factorial experiments introduce students to advanced research methodologies.

PO9: Digital and Technological Skills

CO4 (3): Strongly related as data analysis in DOE often involves statistical software and digital tools.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

CO2 (1): Partially related, as experimental design can consider diverse perspectives in data collection.

PO11: Value Inculcation and Environmental Awareness

CO7 (2): Moderately related, as efficiency in experimental design reduces resource wastage.

PO12: Autonomy, Responsibility, and Accountability

CO3 (2): Moderately related, as designing experiments requires independent decision-making.

PO13: Community Engagement and Service

CO5 (1): Partially related, as factorial experiments can be applied to community-based research projects.

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	: V
Course Type	: Major Mandatory (Practical)
Course Code	: STA-305-MJM
Course Title	: Statistics Practical – V
No. of Credits	: 02
No. of Teaching Hours	: 60

Course Objectives:

1. To understand the situations where and how to use appropriate probability sampling methods.
2. To estimating the population parameters under different sampling techniques.
3. To obtain estimates of standard error under various sampling procedures.
4. To learn how to design and analyse factorial experiments.
5. To identify the design, carryout various experiments and analyse the data.
6. To apply and understand total and partial confounding in real life problems.
7. To develop skills to interpret and draw meaningful conclusions from experimental results.

Course Outcome:

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

CO 1. apply appropriate sample survey design for related problems.

CO 2. estimates the convenient sample size for Simple random sampling and stratified random sampling.

CO 3. apply various sampling techniques, such as simple random sampling, stratified sampling, cluster sampling, and systematic sampling, based on the specific requirements of different research scenarios.

CO 4. develop a sampling plan for a given research question or problem, considering factors such as population characteristics, sampling frame, and research objectives.

CO 5. understand basic principles and various terms of Design of Experiments.

CO 6. apply Factorial design, confounding in real life problems.

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

Topics and Learning Points

Sr. No.	Title of Experiments
1	Simple Random Sampling (Estimation of Population Mean, Population Total with Standard Errors), i) With Replacement, ii) Without Replacement. Confidence Interval for Population Mean and Population Total.
2	Stratified Random Sampling: Proportional and Neyman Allocation, Comparison with SRSWOR.
3	Stratified Random Sampling: Cost and Variance Analysis.
4	Ratio and Regression Methods of Estimation. Comparison with SRSWOR.
5	Analysis of CRD (Equal and Unequal Replications, Pairwise Comparison of Treatments, Using Critical Difference (C.D). Check Normality using Normal Probability Plot.
6	Analysis of RBD (Pairwise Comparison of Treatments using: i) C.D ii) Tukey test iii) Scheff's test.)
7	Analysis of LSD (Pairwise Comparison of Treatments using C.D. and Box Plot)
8	Analysis of 2^2 and 2^3 Factorial Experiments in RBD.
9	Analysis of 2^3 Factorial Experiments in RBD (Total Confounding)
10	Analysis of 2^3 Factorial Experiments in RBD (Partial Confounding)
11	Case Study

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		3						
CO2		3							2				
CO3			3	3			3			2			2
CO4		3			3	2		3				2	
CO5	3						3				2		
CO6	3			3	3			3	2			2	
CO7		3	3	3		2							2

PO1: Comprehensive Knowledge and Understanding

- **CO1 (3)**: Applying sample survey designs requires a deep understanding of statistical principles.
- **CO5 (3)**: Understanding the principles of Design of Experiments (DOE) is fundamental to statistical learning.
- **CO6 (3)**: Factorial design and confounding concepts require strong foundational knowledge.

PO2: Practical, Professional, and Procedural Knowledge

- **CO2 (3)**: Estimating sample size is a crucial practical skill for real-world data collection.
- **CO4 (3)**: Developing a sampling plan involves professional expertise in research methodologies.
- **CO7 (3)**: Applying experimental design principles to real-world problems aligns with industry practices.

PO3: Entrepreneurial Mindset and Knowledge

- **CO3 (2)**: Selecting the right sampling method is useful in market research and business decision-making.
- **CO7 (2)**: Experimental design is critical for product testing and innovation in industries.

PO4: Specialized Skills and Competencies

- **CO3 (3)**: Applying various sampling techniques requires specialized analytical skills.
- **CO6 (3)**: Factorial design and confounding require technical proficiency in experimental analysis.
- **CO7 (3)**: Implementing experimental designs enhances technical and problem-solving skills.

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

- **CO1 (3)**: Selecting the right survey design is a problem-solving activity.
- **CO4 (3)**: Developing a sampling plan involves analytical reasoning.
- **CO6 (3)**: Understanding confounding in factorial designs helps in solving experimental design issues.

PO6: Communication Skills and Collaboration

- **CO4 (2)**: Developing a sampling plan involves communicating research objectives clearly.
- **CO7 (2)**: Presenting experimental designs requires strong communication skills.

PO7: Research-related Skills

- **CO1 (3)**: Applying sampling techniques is essential for conducting research.
- **CO3 (3)**: Proper sampling is key to designing robust experiments.
- **CO5 (3)**: Understanding experimental design principles is fundamental to research methodology.

PO8: Learning How to Learn Skills

- **CO4 (3)**: Developing a sampling plan fosters self-learning and adaptability.
- **CO6 (3)**: Understanding confounding in factorial designs encourages continuous learning.

PO9: Digital and Technological Skills

- **CO2 (2)**: Sample size estimation often involves statistical software.
- **CO6 (2)**: Factorial design analysis requires the use of statistical computing tools.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO3 (2)**: Sampling techniques help in studying diverse populations.

PO11: Value Inculcation and Environmental Awareness

- **CO5 (2)**: Ethical considerations in DOE emphasize responsible experimental design.

PO12: Autonomy, Responsibility, and Accountability

- **CO4 (2)**: Designing a sampling plan requires responsibility in research decisions.
- **CO6 (2)**: Applying factorial design principles requires accountability in data analysis.

PO13: Community Engagement and Service

- **CO3 (2)**: Sampling is essential for community-based research studies.
- **CO7 (2)**: Experimental design can be used to solve local problems and improve 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	: V
Course Type	: Major Elective (Theory)
Course Code	: STA-306-MJE(A)
Course Title	: C – Programming
No. of Credits	: 02
No. of Teaching Hours	: 30

Course Objectives:

Students successfully completing this course will be able:

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

Course Outcomes:

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

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

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

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

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

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

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

Topics and Learning Points

Unit 1: C Fundamental **(6 L)**

1.1 History of 'C' language, Structure of a 'C' program.

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

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

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

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

Unit 2: Control Structure **(8 L)**

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

Unit 3: Array **(8 L)**

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

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

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

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

3.4 To obtain median of given n observations.

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

Unit 4: String **(04)**

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

Unit 4: Function **(04)**

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

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

List of Simple Programs (short programs)

1. Converting °C temperature to °F.
2. To check whether given number is odd or even.
3. To check whether given number m is divisible by n or not.
4. To find maximum of 2 numbers or 3 numbers.
5. To find area of triangle and circle.
6. To find roots of quadratic equation.
7. To check whether integer is prime or not.
8. To find mean, Geometric mean and Harmonic Mean of n numbers.
9. To find sum of digits of a number.
10. To solve simultaneous linear equations. (two equations in two variables)
11. To evaluate simple and compound interest
12. To generate Fibonacci series like 0, 1, 1,2,3,5…

List of programs (long programs)

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

References:

1. Balagurusamy, E. (2019). *Programming in ANSI C* (8th ed.). McGraw-Hill Education.
2. Kanetkar, Y. P. (2021). *Let us C* (18th ed.). BPB Publications.
3. Shah, M. A. (2010). *Programming in C*. Pearson Education India.

4. Pundir, R. (2013). *Computer fundamentals and programming in C*. Katson Books.
5. Thareja, R. (2014). *Programming in C* (2nd ed.). Oxford University Press.
6. Goyal, A., & Goyal, A. (2015). *Programming in C* (2nd ed.). Laxmi Publications.
7. Joshi, P. (2017). *Programming in C*. BPB Publications.
8. Mittal, A. (2016). *Programming in C* (1st ed.). Pearson India Education.
9. Patel, H., & Chothani, D. (2015). *Programming in C* (2nd ed.). Dreamtech Press.
10. Kanetkar, Y. P., & Dhotre, A. A. (2016). *Understanding pointers in C* (4th ed.). BPB Publications.

COs and POs Mapping

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

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

Justifications by Program Outcome (PO)

PO1: Comprehensive Knowledge and Understanding

CO1, CO2, CO3, CO5: These COs develop a strong foundation in programming concepts and problem-solving using C, which are essential for comprehensive knowledge. They are strongly related (Weight: 3).

CO4, CO6, CO7: These COs contribute to the understanding of specific programming features like arrays, strings, and data types. They are moderately related (Weight: 2).

PO2: Practical, Professional, and Procedural Knowledge

CO1-CO7: All COs involve practical skills like problem-solving, modular programming, and using C's built-in functions, which strongly relate to this PO (Weight: 3).

PO3: Entrepreneurial Mindset and Knowledge

CO1, CO2: Programming and algorithmic problem-solving skills can contribute to entrepreneurial thinking, but with less emphasis than other POs (Weight: 2).

CO3-CO7: These COs have limited relation to entrepreneurial mindset development, so they are partially related (Weight: 1).

PO4: Specialized Skills and Competencies

CO2-CO5: Developing and understanding complex programs, control structures, and C syntax builds specialized skills in programming, making these COs strongly related (Weight: 3).

CO1, CO6, CO7: These COs involve basic to moderate specialized skills, making them moderately related (Weight: 2).

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

CO1-CO5: Problem-solving through programming and using control structures or algorithms is central to these COs, making them strongly related (Weight: 3).

CO6, CO7: Applying operators and performing input-output operations contribute to problem-solving but are less complex, so they are moderately related (Weight: 2).

PO6: Communication Skills and Collaboration

CO1, CO2: Collaborating to solve problems using programming and algorithms involves some level of communication and collaboration, making them moderately related (Weight: 2).

CO3-CO7: The other COs involve more individual-focused programming activities, so they are partially related (Weight: 1).

PO7: Research-related Skills

CO2, CO3: Exploring algorithmic approaches and developing modular programs encourage research-oriented thinking, making these COs moderately related (Weight: 2).

CO1, CO4-CO7: These COs are less research-focused and partially related (Weight: 1).

PO8: Learning How to Learn Skills

CO1-CO7: All COs involve learning and applying new programming skills, contributing to lifelong learning, making them moderately related (Weight: 2).

PO9: Digital and Technological Skills

CO1-CO7: Programming in C enhances digital and technological competencies, making all COs moderately related (Weight: 2).

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

CO1-CO7: The programming skills and knowledge in this course do not directly emphasize multicultural competence or empathy, making the COs partially related (Weight: 1).

PO11: Value Inculcation and Environmental Awareness

CO1-CO7: These COs focus more on technical skills, with limited relevance to value inculcation or environmental awareness (Weight: 1).

PO12: Autonomy, Responsibility, and Accountability

CO1-CO7: Programming encourages individual responsibility in solving problems and developing code, making all COs moderately related (Weight: 2).

PO13: Community Engagement and Service

CO1-CO7: Although not directly related, the programming skills acquired could be used in community-focused projects, making these COs partially related (Weight: 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 : V
Course Type : Major Elective (Theory)
Course Code : STA-306-MJE(B)
Course Title : Introduction to Stochastic Processes
No. of Credits : 02
No. of Teaching Hours : 30

Course Objectives:

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

Course Outcomes:

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

CO1. formulate transition probability matrix, n-step transition probabilities
CO2. classify of states of Markov Chain.
CO3. familiar with Poisson process and its properties.
CO4. understanding of stationary distributions in the context of stochastic processes and their key properties.
CO5. explore applications of stationary distributions in various fields, including queueing theory, reliability analysis, and population dynamics.

CO6. develop a deep understanding of the definition and fundamental properties of Poisson process.

CO7. develop skills in using stochastic processes for modeling and forecasting future events and outcomes.

Topics and Learning Points

UNIT 1: Introduction **(10 L)**

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

UNIT 2: Classification of States **(10 L)**

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

UNIT 3: Stationary Distribution **(4 L)**

Stationary distribution for an irreducible ergodic finite M.C., Long run behaviour of a MC

UNIT 4: Poisson Process **(6 L)**

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

References:

1. Medhi J. (1982) Stochastic processes (Wiley Eastern)
2. Ross, S. (1996) Stochastic processes (John Wiley)
3. Ross, S. (2000) Introduction to probability models, 7th edition (Academic Press)
4. Hoel , P.G.,Port, S.C. ,Stone, C.J. (1972) : Introduction to stochastic processes
5. Bhat, B.R. (2000) stochastic models: Analysis and applications (New Age International)

6. Adke, S.R., Manjunath, S.M. (1984) An introduction to finite Markov processes (Wiley Eastern)
7. Taylor, H N and Karlin, S. (1984) An introduction to stochastic modeling(Academic Press)

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	3		3		2				
CO2					3			3					
CO3		3		3			3						
CO4	3											2	
CO5		3	2			3	3			3	3		1
CO6	3							3					
CO7		3	2	3	3	3			2			2	

Justifications for CO-PO Mappings

PO1: Comprehensive Knowledge and Understanding

- **CO1 (3)**: Formulating a transition probability matrix requires a strong conceptual understanding of Markov chains and stochastic processes.
- **CO4 (3)**: Understanding stationary distributions is fundamental to stochastic processes.
- **CO6 (3)**: A deep understanding of Poisson processes is essential in probability theory and stochastic modeling.

PO2: Practical, Professional, and Procedural Knowledge

- **CO3 (3)**: The Poisson process is widely used in real-world applications like risk assessment and reliability modeling.
- **CO5 (3)**: Applications of stationary distributions in queueing theory and reliability analysis align with professional and industry standards.
- **CO7 (3)**: Using stochastic processes for forecasting is a critical professional skill in multiple domains.

PO3: Entrepreneurial Mindset and Knowledge

- **CO5 (2)**: Understanding applications in population dynamics and reliability analysis can help in innovative business solutions.
- **CO7 (2)**: Forecasting future outcomes is essential in entrepreneurial decision-making.

PO4: Specialized Skills and Competencies

- **CO1 (3)**: Working with Markov chains requires analytical and problem-solving skills.

- **CO3 (3)**: Poisson processes are used in predictive modeling and require technical proficiency.
- **CO7 (3)**: Forecasting future events using stochastic models requires specialized skills.

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

- **CO1 (3)**: Transition probability matrices are used in solving real-world stochastic problems.
- **CO2 (3)**: Classifying states in Markov chains is crucial for analytical reasoning in probabilistic modeling.
- **CO7 (3)**: Forecasting involves complex problem-solving and analytical thinking.

PO6: Communication Skills and Collaboration

- **CO5 (2)**: Explaining stochastic applications like queueing theory requires effective communication skills.
- **CO7 (2)**: Presenting forecasting results involves clear communication and collaboration.

PO7: Research-related Skills

- **CO1 (3)**: Markov chain models are essential in research and statistical analysis.
- **CO3 (3)**: Understanding the Poisson process is crucial for research in applied probability.
- **CO5 (3)**: Research applications of stationary distributions in various fields are important for advanced study.

PO8: Learning How to Learn Skills

- **CO2 (3)**: Classifying states in Markov chains helps in developing independent learning skills.
- **CO6 (3)**: Learning the Poisson process and its applications promotes continuous learning.

PO9: Digital and Technological Skills

- **CO1 (2)**: Transition matrices and Markov chains are often implemented using software tools like MATLAB, R, or Python.
- **CO7 (2)**: Stochastic forecasting requires computational tools for simulation and prediction.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO5 (1)**: Stochastic models are used in diverse areas, such as social science and population studies.

PO11: Value Inculcation and Environmental Awareness

- **CO5 (1)**: Understanding population dynamics through stochastic modeling can help in sustainability studies.

PO12: Autonomy, Responsibility, and Accountability

- **CO4 (2)**: Understanding stationary distributions requires self-directed learning and accountability in mathematical modeling.
- **CO7 (2)**: Applying stochastic forecasting techniques independently fosters responsibility in decision-making.

PO13: Community Engagement and Service

- **CO5 (1)**: Applications of stochastic processes in areas like reliability analysis contribute to societal well-being.

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	: V
Course Type	: Major Elective (Theory)
Course Code	: STA-306-MJE(C)
Course Title	: Official Statistics
No. of Credits	: 2 credits
No. of Teaching Hours	: 30

Course Objectives:

1. Indian official statistics pertaining to agriculture, industry and concept of national income and methods of computation.
2. Understanding the functioning of official statistics.
3. Search, evaluation and use of metadata and ability to judge the quality of data on this basis.
4. Use of adequate statistical standards in research
5. Ability to critically evaluate the importance and impact of methods and tools on quality in official statistics
6. Understand the structure and function of national and international Statistical system.
7. Apply official statistical methods and concepts to analyze real-world issues and challenges.

Course Outcomes:

Student will be able to

CO 1. Students become familiar with institutional, legal and organizational bases, and principles of functioning of official statistics.

CO 2. Students able to understand the fundamentals of measurement in official statistics.

CO 3. Students able to judge implications of these bases for the functioning of official statistics and quality of data in official statistics, especially with regard to limitations that arise from measurement and processes of statistical production.

CO 4. Identify the key principles and purposes of producing official statistical data.

CO 5. Understand the factors influencing demand and supply in different markets.

CO 6. Apply official statistical methods and concepts to analyze real-world issues and challenges.

CO 7. Understand how statistical information influences decision-making at different levels.

Topics and Learning Points:

Unit-1 Indian Official Statistics **(10 L)**

1.1 Agricultural Statistics in India

i. Statistics of land utilization

ii. Statistics of crop output

iii. Miscellaneous of crop output (not to be studied in detail)

iv. Indices of agricultural production. Defects of Indian agricultural statistics.

1.2 Price Statistics:

Usefulness of price statistics, wholesale price statistics, index number of wholesale prices. Retail price statisticslabour bureau index, number of retail prices for urban and rural areas, consumer price index for industrial workers, non-manual employees and agricultural labourers, limitations of price statistics.

1.3 Industrial Statistics: primary sources of industrial statistics, statistics collected (description in brief), limitations of industrial statistics, index number of industrial productions. Method of compilation. Index number of industrial profits revised series.

1.4 Educational Statistics: Description of different statistics relating to education, compiled and published by the ministry of education of the India Govt. Number of educational institutions, education of scheduled castes, tribes and backwards classes. Number of scholars, number of teachers, examination result. Sources of publications, critical study of educational statistics in India.

Unit 2 National Income **(4 L)**

2.1 Definition (three approaches: product, income and expenditure). Methods of estimating national income: product method, income method, expenditure method and social accounting method.

Unit 3 Economic Time Series **(8 L)**

3.1 Components of time series

3.2 Decomposition of time series- Additive and multiplicative model with their merits and demerits, Illustrations of time series.

3.3 Measurement of trend by method of free-hand curve, method of semi-averages and method of least squares (linear, quadratic and modified exponential).

3.4 Measurement of seasonal variations by methods of ratio to trend

3.5 Link relative method

3.6 Examples and problem

Unit 4 Demand and Supply Analysis **(8 L)**

4.1 Demand: meaning, statement of law, assumptions, exceptions and determinants of demand, individual and market demand.

4.2 Supply: meaning, statement of law, assumptions, exceptions and determinants of supply, individual and market supply

4.3 Elasticity of demand: definition: i) price elasticity of demand ii) income elasticity of demand iii) cross elasticity of demand

4.4 Method of measuring elasticity of demand: i) percentage method, ii) point method iii) total outlay method iv) ARC Method

4.5 Demand forecasting: meaning need and methods of forecasting

4.6 Examples and problems

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					
CO2	3												
CO3		3		3	3		3				1		
CO4	3					2							
CO5		3	2		3					1			
CO6		3		3	3		3	2	2				1
CO7			2	3		2			2			2	

Justifications for Mapping

PO1: Comprehensive Knowledge and Understanding

- **CO1 (3):** Understanding the institutional, legal, and organizational bases of official statistics requires a strong theoretical foundation.
- **CO2 (3):** Knowledge of measurement fundamentals is essential to comprehending the principles of official statistics.
- **CO4 (3):** Identifying key principles of official statistics requires a deep understanding of methodologies and theoretical frameworks.

PO2: Practical, Professional, and Procedural Knowledge

- **CO3 (3):** Evaluating the quality of official statistics and understanding its limitations is essential for professional statistical practice.
- **CO5 (3):** Analyzing factors influencing market dynamics using official statistics is a key professional skill.
- **CO6 (3):** Applying official statistical methods to real-world problems ensures practical competency.

PO3: Entrepreneurial Mindset and Knowledge

- **CO5 (2):** Understanding demand and supply factors is crucial for business decision-making and market analysis.
- **CO7 (2):** Statistical information helps entrepreneurs make informed decisions and assess risks effectively.

PO4: Specialized Skills and Competencies

- **CO3 (3):** Evaluating the quality of official statistics requires analytical and problem-solving skills.
- **CO6 (3):** Applying statistical methods to analyze real-world issues demonstrates technical proficiency.
- **CO7 (3):** Understanding the impact of statistical information on decision-making is a specialized competency.

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

- **CO3 (3):** Assessing data quality and understanding limitations requires analytical reasoning.
- **CO5 (3):** Analyzing demand and supply dynamics involves applying economic and statistical concepts.
- **CO6 (3):** Applying statistical methods to real-world challenges strengthens problem-solving skills.

PO6: Communication Skills and Collaboration

- **CO4 (2):** Explaining key principles of official statistics requires effective communication.
- **CO7 (2):** Communicating statistical insights to decision-makers is essential in policymaking and business.

PO7: Research-related Skills

- **CO3 (3):** Understanding limitations in official statistics aligns with research-related inquiry and critical analysis.
- **CO6 (3):** Applying statistical methods to real-world challenges enhances research skills.

PO8: Learning How to Learn Skills

- **CO1 (2):** Learning about institutional and legal aspects of official statistics fosters independent learning.
- **CO6 (2):** Applying statistical methods to new challenges promotes continuous learning and adaptability.

PO9: Digital and Technological Skills

- **CO6 (2):** Applying statistical methods often requires using statistical software and ICT tools.
- **CO7 (2):** Accessing and analyzing official statistical data involves digital proficiency.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO5 (1):** Understanding market demand and supply in various sectors involves recognizing diverse economic conditions.

PO11: Value Inculcation and Environmental Awareness

- **CO3 (1):** Recognizing the ethical implications of official statistics aligns with responsible data use.

PO12: Autonomy, Responsibility, and Accountability

- **CO7 (2):** Understanding the role of statistics in decision-making requires responsibility and accountability in data interpretation.

PO13: Community Engagement and Service

- **CO6 (1):** Applying official statistical methods contributes to community-driven research and policy initiatives.

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	: V
Course Type	: Minor (theory)
Course Code	: STA-311-MN
Course Title	: Statistical Techniques-I
No. of Credits	: 2 credits
No. of Teaching Hours	: 30

Course Objectives:

1. To understand the concept of continuous probability distributions and their importance in real-life scenarios.
2. To analyze the characteristics of Chi-square, t, and F-distributions.
3. To understand the use of probability tables for normal, chi-square, t, and F distributions.
4. To understand the concept of hypothesis testing and estimation.
5. To study the properties and applications of parametric and non-parametric tests.
6. To gain proficiency in large sample tests for means and proportions.
7. To understand the relationships among various statistical distributions.

Course Outcomes:

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

CO1 define and calculate p.d.f., mean, and variance for distributions.

CO2 apply the Exponential and Uniform distributions to solve real-life problems.

CO3 demonstrate knowledge of the normal distribution and its applications.

CO4 interpret and use the Chi-square, t, and F-distributions effectively.

CO5 perform hypothesis tests for population means, variances, and proportions.

CO6 analyze data using parametric and non-parametric statistical methods.

CO7 apply large sample tests for population means and proportions.

Topics and Learning Points

UNIT 1: Standard Continuous Probability Distributions **(7L)**

1.1 Uniform Distribution: statement of p.d.f., mean, variance, nature of probability curve.

Theorem (without proof): The distribution function of any continuous r.v. if it is Invertible follows U(0, 1) distribution.

1.2 Exponential Distribution: statement of p.d.f. of the form $f(x) = (1/\theta)\, e(-x/\theta)$, mean, Variance, nature of probability curve, lack of memory property.(without proof)

1.3 Normal Distribution: statement of p.d.f., identification of parameters, nature of Probability density curve, standard normal distribution, symmetry, distribution of aX+b, aX+bY+c where X and Y are independent normal variables, computations of Probabilities using normal probability table, normal approximation to binomial and Poisson distribution, central limit theorem (statement only), normal probability plot.

1.4 Chi-square (χ^2_n) Distribution: Definition of χ^2 r. v. as sum of squares of i.i.d. standard normal variables, nature of p.d.f. curve, computations of probabilities using tables of χ^2 distribution. Mean, variance, β_1, β_2, γ_1, γ_2, mode, additive property.

1.5 Student's t-distribution: Definition of T r. v. with n d.f. in the form $\frac{U}{\sqrt{\chi^2_n / n}}$ where $U \rightarrow N(0, 1)$ and χ^2_n is a χ^2 r. v. with n d.f. and U and χ^2_n are independent r.v.s., nature of probability curve, mean, variance, mode, use of tables of t-distribution for calculation of probabilities, statement of normal approximation.

1.6 Snedecore's F-distribution: Definition of F r.v. with n_1 and n_2 d.f. as $F_{n_1,n_2} = \frac{\chi^2_{n_1} / n_1}{\chi^2_{n_2} / n_2}$ where $\chi^2_{n_1}$ and $\chi^2_{n_2}$ are independent chi-square r.v.s. with n_1 and n_2 d.f. respectively, nature of probability curve, mean, variance, moments, mode, Distribution of $1/F_{n_1,n_2}$, use of tables of F-distribution for calculation of probabilities. Interrelations among, χ^2, t and F variates.

1.7 Numerical problems related to real life situations.

Unit 2: Introduction to Testing of Hypothesis (3 L)

Parameter, random sample from a distribution as i.i.d. r.v.s. $X_1, X_2, \ldots, Xn$, statistic, estimator, estimate, critical region. Statistical hypothesis, null and alternative hypothesis, one sided and two sided alternative hypothesis, p-value. Confidence interval.

Unit 3: Parametric Test:

3.1 Large Sample Tests (Tests based on Normal distribution): (5L)

1) Z-tests for population means: One sample and two sample tests for one-sided and two-sided alternatives
2) Z-tests for population proportions: One sample and two sample tests for one-sided and two-sided alternatives

3.2 Small Sample Tests (Tests based on Normal distribution) : (9L)

1) Tests based on Chi-square distribution: Test for independence of two attributes, Test for Goodness of Fit,
2) Tests based on t-distribution: t-tests for population means: One sample and two sample tests for one-sided and two-sided alternatives, Paired t-test for one-sided and two-sided alternatives.
3) Test based on F-distribution: Test for H_0: $\sigma_1^2 = \sigma_2^2$ against one-sided and two-sided alternatives when means are known and means are unknown.

UNIT-4. Non-parametric Test (6L)

4.1 Introduction to Non-Parametric tests

4.2 sign test

4.3 run test

4.4 Wilcoxon sign rank test

4.5 Kolmogorov – Smirnov test

4.6 Median test

4.7 Mann Whitney test

References:

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4. Trivedi K.S. 2001, Probability, Statistics, Design of Experiments and Queuing Theory with Applications of Computer Science, Prentice Hall of India, New Delhi.
5. Gupta S. C. and Kapoor V. K.1987 Fundamentals of Mathematical Statistics (3rd Edition) S.Chand and Sons, New Delhi
6. Kulkarni M.B., Ghatpande, S.B.,Gore S.D. 1999 Common Statistical Tests, Satyajeet Prakashan,
7. Hogg R. V. and Craig R. G.: Introduction to Mathematical Statistics Ed.4.

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9. Meyer P.L. (1970): Introductory Probability and Statistical Applications, Edition Wesley.
10. Freedman D., Pisani R., Purves R. (2007), Statistics, Fourth Edition, W. W. Nortan and Company, New York

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:** (2) The ability to define and calculate p.d.f., mean, and variance requires a solid understanding of foundational statistical concepts.
- **CO2:** (2) Applying the Exponential and Uniform distributions builds on a foundational understanding of probability theory and distribution properties.
- **CO3:** (2) Understanding the normal distribution and its applications is a core component of statistical theory.
- **CO4:** (2) Using Chi-square, t, and F-distributions requires comprehensive knowledge of statistical methods.
- **CO5:** (2) Hypothesis testing is rooted in deep theoretical knowledge of statistics.
- **CO6:** (2) Analyzing data using parametric and non-parametric methods involves a strong grasp of statistical principles.
- **CO7:** (2) Applying large sample tests and F-tests also requires a solid understanding of underlying statistical theories.

PO2: Practical, Professional, and Procedural Knowledge

- **CO1:** (1) Defining and calculating p.d.f., mean, and variance are fundamental skills that have practical applications in various fields.
- **CO2:** (3) Applying distributions like Exponential and Uniform in real-life scenarios demonstrates practical professional knowledge.
- **CO3:** (3) The normal distribution is widely used in professional statistical analysis, making this CO strongly related to practical knowledge.
- **CO4:** (3) The application of Chi-square, t, and F-distributions is a key practical skill in statistical testing.
- **CO5:** (3) Performing hypothesis tests is a critical professional procedure in data analysis and research.
- **CO6:** (3) The use of parametric and non-parametric methods is essential for practical data analysis in many industries.
- **CO7:** (3) Applying large sample tests and F-tests has direct professional and procedural applications in statistical analysis.

PO3: Entrepreneurial Mindset and Knowledge

- **CO1:** (1) Understanding basic statistical measures can support data-driven decision-making in entrepreneurial contexts.
- **CO2:** (2) Solving real-life problems using distributions can aid in risk assessment and market analysis.
- **CO3:** (1) Knowledge of the normal distribution can support quality control and operational decisions.
- **CO4:** (1) Using statistical distributions in decision-making processes can enhance an entrepreneurial approach.
- **CO5:** (1) Hypothesis testing can support innovation by validating business strategies and processes.
- **CO6:** (2) Analyzing data effectively is crucial for identifying market trends and opportunities.
- **CO7:** (2) Applying large sample tests can assist in making informed business decisions and understanding market dynamics.

PO4: Specialized Skills and Competencies

- **CO1:** (2) Calculating statistical measures develops technical and analytical skills.
- **CO2:** (3) Applying distributions to solve problems enhances problem-solving and analytical competencies.
- **CO3:** (3) Mastery of the normal distribution demonstrates specialized statistical skills.
- **CO4:** (3) Proficiency in using Chi-square, t, and F-distributions is essential for specialized statistical analysis.
- **CO5:** (3) Hypothesis testing requires a high level of analytical reasoning and specialized skills.
- **CO6:** (3) The ability to analyze data using various methods is a key technical competency.
- **CO7:** (3) Conducting large sample tests and F-tests reflects advanced problem-solving skills.

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

- **CO1:** (2) Calculating p.d.f., mean, and variance involves applying mathematical concepts to solve problems.
- **CO2:** (3) Applying distributions directly correlates with solving real-world problems.
- **CO3:** (3) The normal distribution is fundamental to many analytical processes.
- **CO4:** (3) Interpreting statistical distributions requires strong analytical reasoning.
- **CO5:** (3) Hypothesis testing is central to solving data-related problems.
- **CO6:** (3) Analyzing data using statistical methods exemplifies the application of analytical reasoning.
- **CO7:** (3) Applying large sample tests and F-tests involves problem-solving at an advanced level.

PO6: Communication Skills and Collaboration

- **CO1:** (1) Explaining statistical concepts and results improves communication skills.
- **CO2:** (1) Solving real-life problems can require collaboration with others to interpret results.
- **CO3:** (1) Knowledge of the normal distribution helps in communicating statistical findings.

- **CO4:** (1) Effective interpretation of statistical tests requires clear communication.
- **CO5:** (1) Hypothesis testing often involves collaboration in research or business environments.
- **CO6:** (1) Analyzing data and reporting findings requires strong communication skills.
- **CO7:** (1) Large sample tests and F-tests may require collaboration to interpret and report results.

PO7: Research-related Skills

- **CO1:** (2) Calculating p.d.f., mean, and variance is foundational for statistical research.
- **CO2:** (2) Applying distributions in research settings demonstrates the ability to conduct data-driven inquiries.
- **CO3:** (2) Understanding the normal distribution is crucial for many research methodologies.
- **CO4:** (2) Interpreting statistical distributions is a key research skill.
- **CO5:** (2) Hypothesis testing is fundamental to research design and analysis.
- **CO6:** (2) Analyzing data using statistical methods is central to conducting research.
- **CO7:** (2) Applying large sample tests and F-tests supports research-related data analysis.

PO8: Learning How to Learn Skills

- **CO1:** (1) Learning to calculate statistical measures fosters self-directed learning.
- **CO2:** (1) Applying distributions in new contexts encourages continuous learning.
- **CO3:** (1) Mastering the normal distribution involves learning new statistical techniques.
- **CO4:** (1) Interpreting and using statistical tests requires ongoing learning.
- **CO5:** (1) Hypothesis testing involves adapting to new information and techniques.
- **CO6:** (1) Analyzing data using various methods supports the development of self-learning skills.
- **CO7:** (1) Applying large sample tests and F-tests requires continuous adaptation and learning.

PO9: Digital and Technological Skills

- **CO1:** (1) Calculating statistical measures can involve the use of software tools.
- **CO2:** (2) Applying distributions often requires technological tools for data analysis.
- **CO3:** (2) The normal distribution is frequently analyzed using digital tools.
- **CO4:** (2) Statistical tests are commonly conducted using software.
- **CO5:** (2) Hypothesis testing is often performed with the help of technological tools.
- **CO6:** (2) Analyzing data using parametric and non-parametric methods requires digital proficiency.
- **CO7:** (2) Conducting large sample tests and F-tests involves using statistical software.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO1:** (1) Understanding statistical concepts can enhance communication across diverse settings.
- **CO2:** (1) Applying statistical methods can aid in addressing issues in multicultural contexts.
- **CO3:** (1) Knowledge of statistics can support decision-making in diverse environments.
- **CO4:** (1) Interpreting statistical results can foster understanding in multicultural settings.
- **CO5:** (1) Hypothesis testing can be applied to studies involving diverse populations.
- **CO6:** (1) Analyzing data can help address issues related to inclusivity and diversity.
- **CO7:** (1) Large sample tests and F-tests can be used to study diverse populations and issues.

PO11: Value Inculcation and Environmental Awareness

- **CO1:** (1) Statistical knowledge can be applied to study environmental data.
- **CO2:** (1) Applying distributions can support sustainability studies.
- **CO3:** (1) Understanding the normal distribution can aid in environmental data analysis.
- **CO4:** (1) Using statistical tests can help in environmental research.
- **CO5:** (1) Hypothesis testing can be applied to environmental studies.
- **CO6:** (1) Analyzing data can support environmental conservation efforts.

- **CO7:** (1) Large sample tests and F-tests can be used in environmental research.

PO12: Autonomy, Responsibility, and Accountability

- **CO1:** (1) Calculating statistical measures fosters independent problem-solving.
- **CO2:** (2) Applying distributions to solve problems requires accountability and responsibility in data analysis.
- **CO3:** (2) Understanding and applying the normal distribution requires independent analysis.
- **CO4:** (2) Using statistical tests involves responsibility in interpreting results.
- **CO5:** (2) Hypothesis testing requires careful and accountable analysis.
- **CO6:** (2) Analyzing data using statistical methods demonstrates autonomy in research.
- **CO7:** (2) Applying large sample tests and F-tests requires responsibility and accountability in data interpretation.

PO13: Community Engagement and Service

- **CO1:** (1) Understanding statistics can support community-based research and services.
- **CO2:** (1) Applying statistical methods can address community issues.
- **CO3:** (1) Statistical knowledge can be used to benefit community projects.
- **CO4:** (1) Interpreting data can inform community decisions and services.
- **CO5:** (1) Hypothesis testing can support community research initiatives.
- **CO6:** (1) Data analysis can be applied to improve community services.
- **CO7:** (1) Large sample tests and F-tests can

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	: V
Course Type	: Minor (Practical)
Course Code	: STA-312-MN
Course Title	: Minor Statistics Practical – III
No. of Credits	: 02
No. of Teaching Hours	: 60

Course Objectives:

1. To understand the process of fitting an exponential distribution.
2. To learn how to fit a normal distribution and compute expected frequencies
3. Apply R Software to perform hypothesis tests for means based on the normal distribution.
4. Use R Software to test proportions using the normal distribution.
5. Conduct t-tests using R Software for various statistical analyses.
6. Execute F-tests using R Software for comparing variances.
7. Implement chi-square tests using R Software for independence of attributes and goodness of fit.

Course Outcomes:

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

CO1 apply normal and exponential distributions to practical problems.

CO2 apply and interpret large sample tests.

CO3 apply and interpret the small sample tests.

CO4 Conduct hypothesis tests for means, proportions, and distributions using R Software.

CO5 perform non-parametric tests and analyse results.

CO6 compute probabilities for continuous probability distributions.

CO7 describe the nature of discrete and continuous probability distributions.

Topics and Learning Points

Sr. No.	Title of the experiment
1	Fitting of exponential distribution.
2	Fitting of normal distribution and computation of expected frequencies.
3	Applications of normal and exponential distributions.
4	Model sampling from exponential and normal distribution.
5	Computations of probabilities of continuous probability distributions using R Software.
6	Test for means based on normal distribution (Also using R Software)
7	Test for proportions based on normal distribution (Also using R Software)
8	Test based on t distributions (Also using R Software)
9	Test based on F distributions (Also using R Software)
10	Tests based on chi-square distribution (Independence of attributes and Goodness of fit test) (Also using R Software)
11	Non-parametric tests.

Programme Outcomes and Course Outcomes Mapping:

CO-PO Mapping Table

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

Justifications

PO1: Comprehensive Knowledge and Understanding

- **CO1 (3)**: Understanding normal and exponential distributions is fundamental to probability and statistics.
- **CO2 (3), CO3 (3)**: Large and small sample tests require foundational statistical knowledge.
- **CO7 (3)**: Differentiating between discrete and continuous distributions builds a strong theoretical base.

PO2: Practical, Professional, and Procedural Knowledge

- **CO4 (3)**: Using R software for hypothesis testing is an essential professional skill.
- **CO5 (3)**: Performing non-parametric tests helps in real-world applications where standard assumptions may not hold.
- **CO6 (3)**: Probability computations are crucial in applied statistical analysis.

PO3: Entrepreneurial Mindset and Knowledge

- **CO4 (1)**: Data analysis skills support decision-making in business and entrepreneurship.
- **CO5 (1)**: Understanding non-parametric methods helps in flexible problem-solving.

PO4: Specialized Skills and Competencies

- **CO1 (2), CO6 (2)**: Mastery of probability distributions aids in analytical problem-solving.
- **CO4 (3)**: Practical implementation of statistical tests using R software is a valuable technical skill.

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

- **CO2 (3), CO3 (3), CO5 (3)**: Hypothesis testing and non-parametric methods enhance critical thinking and problem-solving skills.

PO6: Communication Skills and Collaboration

- **CO4 (2), CO5 (2)**: Statistical interpretation and reporting results require effective communication.

PO7: Research-related Skills

- **CO4 (3), CO5 (3)**: Hypothesis testing and non-parametric analysis are essential for conducting research.

PO8: Learning How to Learn Skills

- **CO6 (2), CO7 (2)**: Continuous learning is necessary to adapt to evolving statistical methods.

PO9: Digital and Technological Skills

- **CO4 (3)**: Utilizing R software enhances computational and data analysis skills.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO5 (1)**: Non-parametric methods often accommodate diverse and inclusive datasets.

PO11: Value Inculcation and Environmental Awareness

- **CO6 (1)**: Probability models can be applied to environmental studies and sustainability research.

PO12: Autonomy, Responsibility, and Accountability

- **CO4 (2), CO5 (2)**: Conducting independent statistical analyses fosters accountability.

PO13: Community Engagement and Service

- **CO5 (1)**: Non-parametric methods are useful in public health and social research.

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	: V
Course Type	: Vocational Skill Course (Practical)
Course Code	: STA-321-VSC
Course Title	: Statistical Computing Using R Software
No. of Credits	: 02
No. of Teaching Hours	: 60

Course Objectives:

1. To develop skills in graphical representation of data using various plotting techniques in R.
2. To understand the concepts and application of sampling methods, including SRSWOR, SRSWR, stratified, and systematic sampling.
3. To compute probabilities and visualize probability distributions such as gamma, lognormal, Weibull, and uniform distributions.
4. To perform statistical model fitting and hypothesis testing, including normality checks and logistic regression analysis.
5. To apply hypothesis testing techniques using R scripts, verifying assumptions before conducting statistical tests.
6. To analyse variance using one-way and two-way ANOVA, ensuring proper assumption verification.
7. To validate statistical models and test consistency using R programming.

Course Outcomes:

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

CO1 implement fundamental R programming concepts, including vectors, data frames, matrices, and importing/exporting data.

CO2 apply different sampling techniques and use random number tables for sample selection.

CO3 compute and interpret probabilities for various continuous probability distributions and visualize them using R.

CO4 conduct logistic regression analysis and assess model adequacy through residual plots.

CO5 develop R scripts to verify assumptions before hypothesis testing for mean comparisons and paired data.

CO6 Conduct one-way and two-way ANOVA with assumption verification and statistical interpretation.

CO7 Validate statistical models and assess the consistency of statistical results.

Topics and Learning Points

Sr. No.	Name of Experiment	No. of Practical
1.	**Fundamentals of R (**Revision of commands and functions studied in F.Y.B.Sc. and S.Y.B.Sc.) Creating a vector using scan function, other types of objects, creating a data frame using edit command, fix command, getwd command, matrices or arrays, list, Importing data from MS-Excel file Using read.table command, saving the R-output in a file using MS-Excel, concept of R-script file, Graphics using R: (a) High level plotting functions (b) Low level plotting functions (c) Interactive graphic functions	2
2.	**Revision of Diagrams and Graphs:** Stem and leaf diagram. Scatter Plot, histogram for raw data with prob=T option and for both equal and unequal class intervals, Boxplot for one and more than one variables, rod or spike plot, empirical distribution function Saving the diagram and graph in MS-Word file.	2
3.	Use of Random Number Tables to Draw SRSWOR, SRSWR, Stratified Sample and Systematic Sample	1
4.	Computations of probabilities of continuous probability distributions: gamma, Cauchy, lognormal, Weibull, uniform, Laplace, Graphs of pmf/pdf by varying parameters for above distributions.	2
5.	Fitting of Lognormal distribution, testing normality of data by Shapiro Wilks test.	1
6.	Fitting of Logistic regression analysis. Interpretation from residual plot, adequacy of model.	1

7.	Script for verifying the assumptions in testing H_0: $\mu = \mu_0$ and then applying appropriate test. Script for verifying the assumptions in testing H_0: $\mu_1 = \mu_2$ and then applying appropriate test. Script for verifying the assumptions in testing H_0: $\mu_1 = \mu_2$ in paired data and then applying appropriate test.	**2**
8.	Script for verifying the assumptions in testing H_0: $\sigma_1^2 = \sigma_2^2$ and then applying appropriate test. Script for performing number of chi-square tests	**1**
9.	Script for verifying the assumptions in one way ANOVA and then applying appropriate test.	**1**
10.	Script for verifying the assumptions in two way ANOVA and then applying appropriate test.	**1**
11.	Script for the testing consistency	**1**

Programme Outcomes and Course Outcomes Mapping:

CO-PO Mapping Table

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

Justification for PO-CO Mapping

PO1: Comprehensive Knowledge and Understanding

- Strongly related (3) to all COs, as students acquire theoretical and applied statistical knowledge.

PO2: Practical, Professional, and Procedural Knowledge

- Strongly related (3) to all COs, as the course involves implementing R programming, statistical tests, and data analysis techniques.

PO3: Entrepreneurial Mindset and Knowledge

- Partially related (1) as students develop problem-solving abilities, but entrepreneurship is not a core focus.

PO4: Specialized Skills and Competencies

- Strongly related (3) to all COs, as students develop technical and analytical skills in R programming, statistical modeling, and data interpretation.

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

- Strongly related (3) to all COs, as students apply statistical methods to real-world data, analyze trends, and interpret results.

PO6: Communication Skills and Collaboration

- Moderately related (2) to hypothesis testing (CO5, CO6, CO7), as students need to present and interpret statistical results.

PO7: Research-related Skills

- Strongly related (3) to CO3–CO7, as students conduct hypothesis tests, model validation, and statistical analysis.

PO8: Learning How to Learn Skills

- Moderately related (2) to all COs, as students independently learn and adapt statistical techniques.

PO9: Digital and Technological Skills

- Strongly related (3) to all COs, as students use R software for data analysis and visualization.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- Partially related (1) to all COs, as statistical applications can be used for diverse social and economic studies.

PO11: Value Inculcation and Environmental Awareness

- Partially related (1) as ethical considerations in data analysis are relevant but not a primary focus.

PO12: Autonomy, Responsibility, and Accountability

- Moderately related (2) as students independently develop scripts, validate models, and apply statistical tests.

PO13: Community Engagement and Service

- Partially related (1) as statistical knowledge can be applied in community-based research but is not the primary focus.