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

For Department of Statistics

Tuljaram Chaturchand College of Arts, Science and Commerce, Baramati

Choice Based Credit System Syllabus

As Per NEP 2.0 (2024 Pattern)

To be implemented from Academic Year 2026 – 2027

Title of the Programme: T.Y.B.Sc. (Statistics)

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)

Sr. No.	Name of Members	Designation
1.	**Prof. Dr. Kakade Vikas Chintaman** Head & Professor, Department of Statistics, T. C. College, Baramati.	**Chairperson**
2.	**Prof. Dr. Jagtap Avinash Srirangrao** Principal, Department of Statistics, T. C. College, Baramati	Member
3.	**Dr. Dhane Neeta Kishor** Associate Professor, Department of Statistics, T. C. College, Baramati	Member
4.	**Dr. Patil Vaishali Vilas** Associate Professor, Department of Statistics, T. C. College, Baramati	Member
5.	**Dr. Swami Chandrashekhar Panchayya** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
6.	**Ms. Wadkar Sarita Dipak** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
7.	**Dr. Malusare Priti Sandeep** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
8.	**Dr. Jagtap Nilambari Arvind** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
9.	**Dr. Gaikwad Pooja Sujit** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
10.	**Ms. Kalange Tejshri Chetan** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
11.	**Dr. Arekar Trupti Shantanu** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
12.	**Miss. Rakate Priya Nanasaheb** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member

13.	**Ms. Choudhar Shital Balu** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
14.	**Miss. Dhokchaule Rutuja Babasaheb** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
15.	**Miss. Ghadge Kiran Tanaji** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
16.	**Miss. Ranmode Snehal Sanjay** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
17.	**Miss. Prabhune Utkarsha Shrinivas** Assistant Professor, Department of Statistics, T. C. College, Baramati	Member
18.	**Dr. Akanksha Kashikar**	Vice-Chancellor Nominee Subject Expert from SPPU, Pune
19.	**Dr. Koshti Rohan**	Subject Expert from Outside the Parent University
20.	**Prof. Gardi Chandrakant Gopal**	Subject Expert from Outside the Parent University
21.	**Mr. Kadam Saurabh**	Representative from industry/corporate sector/allied areas
22.	**Dr. Limbore Jaya Laxman**	Member of the College Alumni
23.	**Miss. Shirke Shatakshi Shrikant**	UG Student
24.	**Miss. Pathak Siddhi Rajendra**	PG Student

Anekant Education Society's

Tuljaram Chaturchand College

of Arts, Science & Commerce, Baramati.

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

Program Outcomes for B.Sc.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Programme Specific Outcomes (PSOs)

PSO1. Proficiency in basic statistical calculations: Students should develop the ability to perform basic statistical calculations, such as measures of central tendency, measures of dispersion, and probabilities. They should be able to use appropriate formulas and procedures to calculate these measures accurately.

PSO2. Competence in data collection and organization: Students should gain practical skills in collecting and organizing data for statistical analysis. They should be able to identify different types of data (categorical, numerical) and employ appropriate methods for data collection.

PSO3. Understanding of graphical representation of data: Students should be able to create and interpret basic graphical representations of data, such as histograms, bar charts, scatter plots, and box plots. They should understand the purpose of these visualizations and how they can aid in data analysis and interpretation.

PSO4. Effective communication of statistical results: Students should practice effectively communicating statistical results. They should be able to present findings in a clear and concise manner, both orally and in written form, using appropriate statistical terminology.

PSO5. Competence in statistical software and programming: Students should gain proficiency in using statistical software packages (e.g., R, Python, SPSS) and programming languages commonly used in statistical analysis. They should be able to efficiently manipulate, analyse, and visualize data using these tools.

PSO6. Development of critical thinking and problem-solving skills: Students should develop the ability to think critically and solve statistical problems using appropriate techniques. They should be able to identify the correct statistical method for a given problem and apply it effectively.

PSO7. Application of statistical software for data analysis: Students should gain hands-on experience with statistical software packages, such as R or Excel, to perform basic data analysis tasks. They should be able to input data, perform calculations, generate graphical representations, and interpret the results.

Credit Distribution Structure for Three/Four Year Honours/Honours with Research Degree Programme With Multiple Entry and Exit options as per National Education Policy (2024 Pattern as per NEP-2020)

Level/ Difficulty	Sem	Subject DSC-1				Subject DSC-2	Subject DSC-3	GE/OE	SEC	IKS	AEC	VEC	CC	Total
4.5/100	I	2(T)+2(P)				2(T)+2(P)	2(T)+ 2(P)	2(T)	2 (T/P)	2(T) (Generic)	2(T)	2(T)	--	22
	II	2(T)+2(P)				2(T)+2(P)	2(T)+2(P)	2(P)	2 (T/P)	--	2(T)	2(T)	2(T	22
Exit option: Award of UG Certificate in Major with 44 credits and an additional 4 credits core NSQF course/Internship OR Continue with Major and Minor **Continue option**: Student will select one subject among the (subject 1, subject 2 and subject 3) as major and other as minor and third subject will be dropped.														
Level/ Difficulty	**Sem**	**Credits Related to Major**				**Minor**	--	**GE/OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP/OJT/CEP/RP**									
5.0/200	III	4(T)+2(P)	--	2 (T/P)	2(FP)	2(T)+2(P)	--	2(T)	--	2(T)	2(T)	--	2(T)	22
	IV	4(T)+2(P)	--	2 (T/P)	2(CEP)	2(T)+2(P)	--	2(P)	2 (T/P)	--	2(T)	--	2(T)	22
Exit option: Award of UG Diploma in Major and Minor with 88 credits and an additional 4credits core NSQF course/Internship OR Continue with Major and Minor														
5.5/300	V	8(T)+4(P)	2(T)+2(P)	2 (T/P)	2(FP/CEP)	2(T)	--	--	--	--	--	--	--	22
	VI	8(T)+4(P)	2(T)+2(P)	2 (T/P)	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 3Years		**44**	**8**	**8**	**10**	**18**	**8**	**8**	**6**	**4**	**8**	**4**	**6**	**132**
Exit option: Award of **UG Degree in Major** with 132 credits OR Continue with Major and Minor														
6.0/400	VII	6(T)+4(P)	2(T)+2 (T/P)	--	4(RP)	4(RM)(T)	--	--	--	--	--	--	--	22
	VIII	6(T)+4(P)	2(T)+2 (T/P)	--	6(RP)	--	--	--	--	--	--	--	--	22
Total 4Years		**64**	**16**	**8**	**22**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours with Research Degree** in Major and Minor with 176 credits														
6.0/400	VII	10(T)+4(P)	2(T)+2 (T/P)	--	--	4(RM) (T)	--	--	--	--	--	--	--	22
	VIII	10(T)+4(P)	2(T)+2 (T/P)	--	4 (OJT)	--	--	--	--	--	--	--	--	22
Total 4Years		**72**	**16**	**8**	**14**	**22**	**8**	8	**6**	**4**	**8**	**4**	**6**	**176**
Four Year **UG Honours Degree** in Major and Minor with 176 credits														

T = Theory **P =** Practical **DSC =** Discipline Specific Course **OE =** Open Elective **SEC =** Skill Enhancement Course
IKS = Indian Knowledge System **AEC =** Ability Enhancement Course **VEC =** Value Education Course **CC =** Co-curricular Course
VSC= Vocational Skill Course **OJT**= On Job Training **CEP**= Community Engagement Project **FP**= Field Project **RP**= Research Project

Course Structure for F.Y.B.Sc. (2024 Pattern as per NEP- 2.0)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	Credits
I	DSC-I (General)	-101-GEN		T	02
		-102-GEN		P	02
	DSC-II (General)	-101-GEN		T	02
		-102-GEN		P	02
	DSC-III (General)	STA-101-GEN	Descriptive Statistics	T	02
		STA-102-GEN	Statistics Practical-I	P	02
	Open Elective (OE)	STA-103-OE	Commercial Statistics	T	02
	Skill Enhancement Course (SEC)	STA-104-SEC	Statistical Computing using MS-Excel	P	02
	Ability Enhancement Course (AEC)	ENG-104-AEC		T	02
	Value Education Course (VEC)	ENV-105-VEC		T	02
	Generic Indian Knowledge System (GIKS)	GEN-106-IKS		T	02
				Total Credits Semester- I	**22**
II	DSC-I (General)	-151-GEN		T	02
		-152-GEN		P	02
	DSC-II (General)	-151-GEN		T	02
		-152-GEN		P	02
	DSC-III (General)	STA-151-GEN	Discrete Probability and Probability Distributions – I	T	02
		STA-152-GEN	Statistics Practical-II	P	02
	Open Elective (OE)	STA-153-OE	Introduction to MS-Excel and Statistical Computing	P	02
	Skill Enhancement Course (SEC)	STA-154-SEC	Application of Statistics Using Advanced Excel	P	02
	Ability Enhancement Course (AEC)	ENG-154-AEC		T	02
	Value Education Course (VEC)	COS-155-VEC		T	02
	Co-curricular Course (CC)	YOG/PES/CUL/NSS/NCC-156-CC	To be selected from the CC Basket	T	02
				Total Credits Semester- II	**22**
				Cumulative Credits Semester I + Semester II	**44**

Course Structure for S.Y.B.Sc. (2024 Pattern as per NEP- 2.0)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	Credits
III	Major Mandatory	STA-201-MRM	Discrete Probability and Probability Distributions - II	Theory	02
	Major Mandatory	STA-202-MRM	Continuous Probability Distributions – I	Theory	02
	Major Mandatory	STA-203-MRM	Major Statistics Practical – I	Practical	02
	Vocational Skill Course (VSC)	STA-204-VSC	Practicals on Predictive Techniques	Practical	02
	Field Project (FP)	STA-205-FP	Field Project	Practical	02
	Minor	STA-206-MN	Probability Distributions and its Applications	Theory	02
	Minor	STA-207-MN	Minor Statistics Practical – I	Practical	02
	Open Elective (OE)	STA-208-OE	Applied Statistical Techniques	Theory	02
	Subject Specific Indian Knowledge System (IKS)	STA-209-IKS	Evolution of Science and Statistics in India	Theory	02
	Ability Enhancement Course (AEC)	MAR-210-AEC / HIN-210-AEC / SAN-210-AEC		Theory (Any One)	02
	Co-curricular Course (CC)	YOG/PES/CUL/ NSS/NCC-211-CC	To be continued from the Semester - II		02
	Total Credits Semester-III				**22**
IV	Major Mandatory	STA-251-MRM	Statistical Techniques	Theory	02
	Major Mandatory	STA-252-MRM	Continuous Probability Distributions – II	Theory	02
	Major Mandatory	STA-253-MRM	Major Statistics Practical – II	Practical	02
	Vocational Skill Course (VSC)	STA-254-VSC	Statistical Process Control	Theory	02
	Community Engagement Project (CEP)	STA-255-CEP	Community Engagement Project	Practical	02
	Minor	STA-256-MN	Predictive Techniques	Theory	02
	Minor	STA-257-MN	Practicals on Predictive Techniques	Practical	02
	Open Elective (OE)	STA-258-OE	Practical Based on Applied Statistical Techniques	Practical	02
	Skill Enhancement Course (SEC)	STA-259-SEC	Introduction to Tableau and Power BI	Practical	02
	Ability Enhancement Course (AEC)	MAR-260-AEC / HIN-260-AEC / SAN-260-AEC		Theory (Any One)	02
	Co-curricular Course (CC)	YOG/PES/CUL/ NSS/NCC-261-CC	To be continued from the Semester - III		02
	Total Credits Semester-IV				**22**
	Total Credits Semester III + IV				**44**

Course Structure for T.Y.B.Sc. Statistics (2024 Pattern as per NEP- 2.0)

Sem	Course Type	Course Code	Course Title	Theory/ Practical	Credits
V	Major Mandatory	STA-301-MRM	Distribution Theory – I	Theory	02
	Major Mandatory	STA-302-MRM	Theory of Estimation	Theory	02
	Major Mandatory	STA-303-MRM	Sampling Methods	Theory	02
	Major Mandatory	STA-304-MRM	Design of Experiments	Theory	02
	Major Mandatory	STA-305-MRM	Major Statistics Practical – III	Practical	02
	Major Mandatory	STA-306-MRM	Major Statistics Practical – IV	Practical	02
	Major Elective (MJE)	STA-307-MJE(A)	Introduction to Stochastic Processes	Theory (Any One)	02
	Major Elective (MJE)	STA-307-MJE(B)	Actuarial Statistics		
	Major Elective (MJE)	STA-308-MJE(A)	Basic Python	Practical (Any One)	02
	Major Elective (MJE)	STA-308-MJE(B)	C- Programming		
	On Job Training (OJT)	STA-309-OJT	On Job Training	Practical	04
	Minor	STA-310-MN	Statistical Inference	Theory	02
	Total Credits Semester – V				**22**
VI	Major Mandatory	STA-351-MRM	Distribution Theory – II	Theory	02
	Major Mandatory	STA-352-MRM	Testing of Hypothesis	Theory	02
	Major Mandatory	STA-353-MRM	Industrial Statistics	Theory	02
	Major Mandatory	STA-354-MRM	Operations Research	Theory	02
	Major Mandatory	STA-355-MRM	Major Statistics Practical – V	Practical	02
	Major Mandatory	STA-356-MRM	Major Statistics Practical – VI	Practical	02
	Major Elective (MJE)	STA-357-MJE(A)	Medical Statistics	Theory (Any One)	02
	Major Elective (MJE)	STA-357-MJE(B)	Official Statistics		
	Major Elective (MJE)	STA-358-MJE(A)	Practical (A)	Practical (Any One)	02
	Major Elective (MJE)	STA-358-MJE(B)	Practical (B)		
	Vocational Skill Course (VSC)	STA-359-VSC	Introduction to Regression Analysis	Theory	02
	Vocational Skill Course (VSC)	STA-360-VSC	Statistical Computing Using R – Software	Practical	02
	Field Project/CEP	STA-361-FP	Field Project	Practical	02
	Total Credits Semester-VI				**22**
	Total Credits Semester V + VI				**44**

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2024 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-MRM

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 ; 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 ; 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 ɑX + 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	-

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

Justification of CO-PO Mapping:

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 (2024 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-MRM

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 $f(x ; \theta) = Exp\{-(x- \theta)\}$, $x > \theta$.

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.

References:

1. Kale B. K. and Murlidharan K. (2015) Introduction to Parametric Inference, Narosa Publication House, New Delhi.

2. Rohatagi, V. K. (1975) An introduction to Probability Theory and Mathematical Statistics, Wiley Eastern Ltd., New Delhi.

3. Lehman E. L. (1988) Theory of point estimation (John Wiley)

4. Dudeweitz, E. J. and Mishra, S. N. (1988) Modern Mathematical Statistics, John Wiley and Sons, Inc.

5. Hoel, P. G. Port, S. and Stone, C. (1972) Introduction to Statistical Theory, Houghton

Mifflin Company (International) Dolphin Edition.

6. Hogg, R. V. and Craig, A. T. (1978) Introduction to Mathematical Statistics (fourth edition), Collier Macmillan International Edition, Macmillan Publishing Co. Inc., New York

7. Kendall, M. and Stuart, A. (1943) The advanced Theory of Statistics, Vol- 1, Charles and Company Ltd., London

8. Lindgren, B. W. (1976) Statistical Theory (third edition) Collier Macmillan International Edition, Macmillan Publishing Co., Inc. New York

9. Mood, A. M., Graybill, F. and Bose, D. C. (1974). Introduction to the theory of Statistics (third edition) International Student Edition, McGraw Hill.

10. Ramchandran, K. M. and Tsokos C. P. (2009). Mathematical Statistics with Applications, Academic Press.

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

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

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

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

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

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

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 (2024 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-MRM

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.
3. Mukhopadhyay P (2008) Sampling theory and methods of survey sampling. Prentice-Hall of India, New Delhi.
4. Murthy, M. N. (1967) Sampling methods, Indian Statistical Institute, Kolkata.
5. Singh, D. and Chaudhary, F. S. (1986) Theory and Analysis of Sample Survey Designs, Wiley Eastern Ltd., New Delhi.
6. Sukhatme, P. V., Sukhatme, B. V. (1984) Sampling theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.

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	-	-	-	2	3	3	-	-	-	2	-
CO5	3	-	-	-	-	-	-	-	-	-	2	-	-
CO6	-	-	-	-	-	-	-	3	-	-	-	-	2
CO7	-	3	2	3	-	-	-	-	2	-	-	-	-

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

Justification of CO-PO Mapping:

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 (2024 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-MRM

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:

C O . 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.

1.3 Choice of size and shape of a plot.

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

1.5 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.

2. Dass, M. N. and Giri, N. C. (1986) Design and Analysis of Experiments, II Edition Wiley Eastern Ltd., New Delhi

3. Federer W. T. (1967) Experimental Design: Oxford and IBH Publishing Co., New Delhi

4. Goon, A.M., Gupta, M. K. and Dasgupta, B. (1998). Fundamentals of Statistics, Vol. II, The world Press Pvt. Ltd. Kolkatta

5. Gupta S. C. and Kapoor V. K. (2006). Fundamentals of Applied Statistics, S. Chand Sons, New Delhi.

6. Johnson, R. A., Miller, I. and Freund, J. (2010). Probability and Statistics for engineers, Prentice Hall, India.

7. Kempthorne, O. (1952). Design of Experiments, Wiley Eastern Ltd., New Delhi.

8. Montgomery, D. C. (2001). Design and Analysis of Experiments, John Wiley and sons Inc., New Delhi.

9. Snedecor, G. W. and Cochran, W. G. (1994). Statistical Methods, 8th edition, Affiliated East – West Press, New Delhi.

10. Wu, C. F. J. and Hamda, M. (2009). Experiments, Planning, Analysis and Parameter Design Optimization, John Wiley & Sons, Inc., Hoboken, New Jersey.

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	-	-

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

Justification of CO-PO Mapping:

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 (2024 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-MRM
Course Title	**:** Major Statistics Practical – III
No. of Credits	**:** 02
No. of Teaching Hours	**:** 60

Course Objectives:

1. To understand and apply principles of probability sampling techniques including SRSWR, SRSWOR and stratified sampling
2. To estimating the population parameters under different sampling techniques.
3. To obtain estimates of standard error under various sampling procedures.
4. To apply advanced estimation techniques such as ratio and regression methods and compare their efficiency with SRSWOR.
5. To analyse cost and variance trade-offs in stratified sampling including proportional and Neyman allocation
6. To develop analytical and computational skills to solve real-life case studies and determine optimum sample size.
7. To model and visualize probability distributions such as Beta, Cauchy and Weibull using density, reliability and hazard functions.

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. apply ratio and regression estimators and assess their relative efficiency over simple random sampling.

CO 6. determine appropriate sample size under specified precision and confidence level.

CO 7. generate and interpret density plots of Beta (first and second kind), Cauchy distributions and reliability & hazard plots of Weibull distribution for practical applications.

Topics and Learning Points

Sr. No.	Title of Experiments
1	Simple Random Sampling (Estimation of Population Mean, Population Total with Standard Errors), With Replacement. Confidence Interval for Population Mean and Population Total.
2	Simple Random Sampling (Estimation of Population Mean, Population Total with Standard Errors), Without Replacement. Confidence Interval for Population Mean and Population Total.
3	Stratified Random Sampling: Proportional and Neyman Allocation, Comparison with SRSWOR.
4	Stratified Random Sampling: Cost and Variance Analysis.
5	Ratio methods of estimation. Comparison with SRSWOR.
6	Regression methods of estimation. Comparison with SRSWOR.
7	Determination of Sample Size.
8	Density plot of Beta distribution of first and second kind, Cauchy distribution
9	Plot of Reliability and Hazard function of Weibull distribution.
10	Construction of confidence interval for population median and quartiles, based on order statistics.
11	Case Study (Equivalent to 2 Practical)

Programme Outcomes and Course Outcomes Mapping:

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

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

Justification of CO-PO Mapping:

PO1: Comprehensive Knowledge and Understanding

- CO1 (Weightage: 3) – Strong understanding of sample survey design builds foundational theoretical knowledge.
- CO2 (Weightage: 3) – Estimation of sample size requires conceptual understanding of sampling theory.
- CO3 (Weightage: 3) – Knowledge of various sampling techniques strengthens theoretical base.
- CO4 (Weightage: 3) – Developing sampling plans integrates theoretical concepts comprehensively.
- CO5 (Weightage: 3) – Ratio and regression estimators require deep statistical understanding.
- CO6 (Weightage: 3) – Precision-based sample size determination involves core theoretical knowledge.
- CO7 (Weightage: 2) – Distribution plots enhance conceptual understanding but are more application-oriented.

PO2: Practical, Professional, and Procedural Knowledge

- CO1 (2) – Application of survey design reflects procedural competence.
- CO2 (3) – Sample size estimation is a key professional skill in research.
- CO3 (3) – Selecting appropriate sampling techniques is industry-relevant.
- CO4 (3) – Developing complete sampling plans aligns strongly with professional practice.
- CO5 (3) – Efficiency comparison is essential in applied survey research.

- CO6 (3) – Practical estimation of required sample size supports professional research work.
- CO7 (2) – Distribution plotting supports applied statistical practice.

PO3: Entrepreneurial Mindset and Knowledge

- CO4 (2) – Designing efficient sampling plans encourages cost-effectiveness and resource optimization.
- Other COs have minor relevance (Weightage: 1) as sampling efficiency indirectly supports business decision-making.

PO4: Specialized Skills and Competencies

- CO1–CO6 (3) – Strong analytical and problem-solving skills are required for sampling design, estimation, and efficiency assessment.
- CO7 (3) – Interpretation of statistical distributions demonstrates specialized analytical competence.

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

- CO1–CO6 (3) – All involve applying statistical methods to solve real-world survey problems.
- CO7 (3) – Interpretation of reliability and hazard plots requires analytical reasoning.

PO6: Communication Skills and Collaboration

- CO4 (2) – Developing and presenting sampling plans requires communication skills.
- CO1, CO3, CO7 (1) – Minor relevance through reporting and interpretation.

PO7: Research-related Skills

- CO4 (3) – Designing sampling plans is central to research methodology.
- CO5 (3) – Efficiency comparison reflects advanced research analysis.
- CO1, CO2, CO3, CO6 (2) – Support research design and data collection.
- CO7 (2) – Distribution analysis supports applied research.

PO8: Learning How to Learn Skills

- CO4 (2) – Developing sampling plans encourages independent analytical thinking.
- CO7 (2) – Learning new distributional tools promotes self-directed learning.
- Other COs (1) support adaptive learning through application.

PO9: Digital and Technological Skills

- CO7 (3) – Strong digital skill requirement for generating density and hazard plots using statistical software.
- CO1–CO6 (2) – Use of statistical software for estimation and sampling procedures.

PO10: Multicultural Competence and Empathy

- CO4 (1) – Survey design may consider diverse populations.

PO11: Value Inculcation and Environmental Awareness

- CO4 (1) – Ethical considerations in survey design.

PO12: Autonomy, Responsibility, and Accountability

- CO4 (3) – Independent development of sampling plan demonstrates accountability.
- CO1–CO3, CO5–CO7 (2) – Independent application of sampling techniques.

PO13: Community Engagement and Service

- CO4 (2) – Survey design applicable to community-based research.

Other COs (1) indirectly support societal data-based decision-making.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2024 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-306-MRM
Course Title	**:** Major Statistics Practical – IV
No. of Credits	**:** 02
No. of Teaching Hours	**:** 60

Course Objectives:

1. To learn how to design and analyse factorial experiments.
2. To identify the design, carryout various experiments and analyse the data.
3. To apply and understand total and partial confounding in real life problems.
4. To develop skills to interpret and draw meaningful conclusions from experimental results.
5. To incorporate covariates in experimental analysis using Analysis of Covariance (ANCOVA) in CRD and RBD.
6. To apply non-parametric techniques such as Kruskal–Wallis H test when ANOVA assumptions are violated.
7. To evaluate efficiency of different designs such as RBD and LSD relative to CRD.

Course Outcome:

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

CO 1. understand basic principles and various terms of design of experiments.

CO 2. apply factorial design, confounding in real life problems.

CO 3. analyze the data of various experimental design.

CO 4. analyze factorial designs, exploring the effects of multiple factors and their interactions on the response variable.

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

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

CO 7. Apply Kruskal–Wallis H test for non-normal data and interpret results appropriately.

Topics and Learning Points

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

COs and POs Mapping

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

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

Justification of CO-PO Mapping:

PO1: Comprehensive Knowledge and Understanding

- CO1 (3): Provides foundational knowledge of principles and terminology of Design of Experiments (DOE).
- CO2 (3): Strong theoretical understanding of factorial design and confounding.
- CO3 (3): Data analysis in experimental designs strengthens conceptual clarity.
- CO4 (3): Understanding interaction effects enhances depth of subject knowledge.

- CO5 (3): Fractional factorial designs require strong theoretical base.
- CO6 (2): Interpretation builds applied understanding.
- CO7 (2): Non-parametric test knowledge adds conceptual breadth.

PO2: Practical, Professional, and Procedural Knowledge

- CO2 (3): Application of factorial design directly relates to industry experiments.
- CO3 (3): Analyzing experimental data is a core professional competency.
- CO4 (3): Studying interaction effects supports real-life experimentation.
- CO5 (3): Fractional designs improve efficiency in industrial experiments.
- CO1, CO6, CO7 (2): Support procedural and applied statistical practices.

PO3: Entrepreneurial Mindset and Knowledge

- CO2 (2): Efficient experimental planning supports cost-effective innovation.
- CO4 (2): Multi-factor analysis aids decision-making in production systems.
- CO5 (2): Fractional designs reduce resources, aligning with business optimization.
- Other COs (1): Indirect contribution to decision-making ability.

PO4: Specialized Skills and Competencies

- CO2–CO5 (3): Strong technical and analytical skills in experimental planning and analysis.
- CO6 (3): Interpretation and conclusion drawing reflects high analytical competence.
- CO7 (3): Application of Kruskal–Wallis test demonstrates specialized statistical skills.
- CO1 (2): Builds technical foundation.

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

- CO2–CO5 (3): Applying and analyzing experimental designs involves high-level problem-solving.
- CO6 (3): Drawing meaningful conclusions requires critical reasoning.
- CO7 (3): Handling non-normal data develops analytical adaptability.
- CO1 (2): Supports analytical understanding.

PO6: Communication Skills and Collaboration

- CO6 (2): Interpretation and presentation of results require communication skills.
- CO2–CO5 (1): Reporting experimental findings contributes moderately.

PO7: Research-related Skills

- CO3 (3): Data analysis is central to research methodology.
- CO4 (3): Studying factor interactions supports research inquiry.
- CO5 (3): Fractional designs are important in research experimentation.

- CO6 (3): Drawing conclusions aligns with research reporting.
- CO1, CO2, CO7 (2): Provide methodological research skills.

PO8: Learning How to Learn Skills

- CO5 (2): Learning advanced experimental techniques enhances self-learning.
- CO6 (2): Independent interpretation fosters autonomous learning.
- Other COs (1): Support adaptive learning.

PO9: Digital and Technological Skills

- CO2–CO5 (2): Use of statistical software for DOE analysis.
- CO7 (2): Software-based implementation of non-parametric tests.
- CO1, CO6 (1): Limited technological relevance.

PO12: Autonomy, Responsibility, and Accountability

- CO6 (3): Independent interpretation and decision-making.
- CO2–CO5 (2): Independent execution of experiments and analysis.
- CO1 (1): Foundational support.

PO13: Community Engagement and Service

- CO2–CO7 (1): Experimental design applicable in agriculture, healthcare, and community-based studies.

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2024 Pattern)

Name of the Programme : B.Sc. Statistics
Programme Code : USST
Class : T.Y.B.Sc.
Semester : V
Course Type : Major Elective (MJE) (Theory)
Course Code : STA-307-MJE(A)
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 modelling 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 queuing 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 modelling 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	-

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

Justification of CO-PO Mapping:

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 modelling.

PO2: Practical, Professional, and Procedural Knowledge

- **CO3 (3)**: The Poisson process is widely used in real-world applications like risk assessment and reliability modelling.
- **CO5 (3)**: Applications of stationary distributions in queuing 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 Mind-set 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 modelling.
- **CO7 (3)**: Forecasting involves complex problem-solving and analytical thinking.

PO6: Communication Skills and Collaboration

- **CO5 (2)**: Explaining stochastic applications like queuing 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 modelling can help in sustainability studies.

PO12: Autonomy, Responsibility, and Accountability

- **CO4 (2)**: Understanding stationary distributions requires self-directed learning and accountability in mathematical modelling.

- **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 (2024 Pattern)

Name of the Programme : B.Sc. Statistics
Program Code : USST
Class : T.Y.B.Sc.
Semester : V
Course Type : Major Elective (MJE)(Theory)
Course Code : STA-307-MJE(B)
Course Title : Actuarial Statistics
No. of Credits : 2 credits
No. of Teaching Hours : 30

Course Objectives:

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

Course Outcomes:

By the end of the course student will be able to

CO 1. identify and analyse consequences of events involving risk and uncertainty.
CO 2. calculate survival function, curtate future lifetime, force of mortality.
CO 3. calculate various payments from life tables using principle of equivalence, net premiums, prospective and retrospective reserve.
CO 4. understand the principles of risk management and how they apply to actuarial practice.

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

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

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

Topics and Learning Points:

Unit-1: Insurance Business (4L)

1.1 Insurance companies as business organizations.

1.2 Role of insurance business in Economy.

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

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

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

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

2.1 Measurement of adverse financial impact, expected value principle.

2.2 Concept of utility function

2.3 Feasibility of insurance business.

2.4 Illustrative examples.

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

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

3.2 Force of mortality.

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

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

3.5 Construction of life table using random survivorship approach.

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

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

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

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

Unit-5: Annuity (5L)

5.1 Annuities – certain, annuity due, annuity immediate.

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

Unit- 6: Benefit Premiums (5L)

6.1 Concept of a loss at issue random variable.

6.2 Equivalence principle

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

6.4 Variance of loss random variable.

References:

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

Programme Outcomes and Course Outcomes Mapping:

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

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

Justification of CO-PO Mapping:

PO1 – Comprehensive Knowledge

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

PO2 – Practical, Professional, and Procedural Knowledge

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

PO3 – Entrepreneurial Mindset

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

PO4 – Specialized Skills and Competencies

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

PO5 – Application, Problem-Solving, and Analytical Reasoning

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

PO6 – Communication Skills and Collaboration

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

PO7 – Research-related Skills

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

PO8 – Learning to Learn

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

PO9 – Digital and Technological Skills

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

PO10 – Multicultural Competence, Empathy

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

PO11 – Ethics and Environmental Awareness

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

PO12 – Autonomy, Responsibility, Accountability

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

PO13 – Community Engagement

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

CBCS Syllabus as per NEP 2020 for T.Y.B. Sc. Statistics (2024 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Program Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** V
Course Type	**:** Major Elective (MJE) (Practical)
Course Code	**:** STA-308-MJE(A)
Course Title	**:** Basic Python
No. of Credits	**:** 2 credits
No. of Teaching Hours	**:** 60

Course Objectives:

1. To introduce students to the Python programming environment and basic syntax.
2. To develop understanding of variables, data types, and operators in Python.
3. To enable students to apply conditional and looping constructs for problem solving.
4. To familiarize students with Python data structures such as lists, tuples, sets, and dictionaries.
5. To enhance skills in string manipulation.
6. To develop the ability to write modular programs using user-defined functions.
7. To provide hands-on experience in file handling for data storage and retrieval.

Course Outcomes:

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

CO1 Set up and work efficiently in the Python programming environment using basic commands.

CO2 Use variables and built-in data types to store and manipulate data in Python programs.

CO3 Apply arithmetic and logical operators to solve computational problems.

CO4 Implement decision-making and looping constructs to control program flow.

CO5 Perform operations on Python data structures such as lists, tuples, sets, and dictionaries.

CO6 Manipulate and process strings using built-in string functions.

CO7 Design and implement reusable code using user-defined functions.

CO8 Develop programs for reading from and writing to files for persistent data storage.

List of Practical

Sr. No.	Title of Experiments	No. of Practical's
1.	Basics of Python • Variables and data types • Basic input and output • Operators and expressions • Comments and style conventions	01
2.	Data Structures • List, tuple, and dictionary, set • Basic operations on data structures • Indexing and slicing • List comprehensions	02
3.	Control Structures • Conditional statements (if, elif, else) • Loops (for and while) • Break and continue statements • Indentation and code blocks	03
4.	Functions • Defining and calling functions • Parameters and arguments • Return statement and function output	03
5.	Introduction to numpy	02
6.	Introduction to pandas	02
7.	Data visualization on using matplotlib and seaborn libraries • Scatter plot, Line plot, Bar plot, Histogram, Box plot, Pair plot	02

References:

1. Charles Severance, Python for Everybody, 1st Edition, CreateSpace Independent Publishing, 2016.

2. Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd Edition, O'Reilly Media, 2015.

3. Reema Thareja, Python Programming Using Problem Solving Approach, Oxford University Press, 2017.

4. E. Balagurusamy, Introduction to Programming Using Python, McGraw Hill Education, 2016.

5. R. Nageswara Rao, Core Python Programming, Dreamtech Press, 2018.

Programme Outcomes and Course Outcomes Mapping:

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

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

Justification of CO-PO Mapping:

PO1: Comprehensive Knowledge and Understanding

- CO1: Demonstrate understanding of Python programming environment and syntax fundamentals. (Weightage: 3)
- CO2: Explain and use variables and built-in data types effectively. (Weightage: 3)
- CO3: Apply arithmetic and logical operators correctly in programs. (Weightage: 3)
- CO4: Understand control flow mechanisms in programming. (Weightage: 3)
- CO5: Explain working of Python data structures. (Weightage: 3)
- CO6: Demonstrate understanding of string manipulation concepts. (Weightage: 2)
- CO7: Understand function design and modular programming principles. (Weightage: 3)

PO2: Practical, Professional, and Procedural Knowledge

- CO1: Set up and operate Python environment efficiently. (Weightage: 2)
- CO4: Implement logical program structures used in industry applications. (Weightage: 3)
- CO5: Use data structures in solving practical computational problems. (Weightage: 3)
- CO7: Develop reusable and structured programs using functions. (Weightage: 3)

PO3: Entrepreneurial Mindset and Knowledge

- CO4: Use logic-building skills helpful in developing innovative software solutions. (Weightage: 2)
- CO5: Apply structured data handling for real-world application development. (Weightage: 2)
- CO7: Design modular solutions encouraging scalable and innovative applications. (Weightage: 2)

PO4: Specialized Skills and Competencies

- CO2: Demonstrate technical proficiency in handling data types. (Weightage: 3)
- CO3: Apply analytical thinking in solving computational problems. (Weightage: 3)
- CO4: Design logical and efficient program flow. (Weightage: 3)
- CO5: Demonstrate problem-solving skills using data structures. (Weightage: 3)
- CO6: Apply string processing techniques effectively. (Weightage: 3)
- CO7: Develop modular and structured programs. (Weightage: 3)

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

- CO3: Solve computational problems using operators. (Weightage: 3)
- CO4: Apply decision-making and looping constructs to solve problems. (Weightage: 3)
- CO5: Analyze and manipulate structured data. (Weightage: 3)
- CO7: Design reusable problem-solving functions. (Weightage: 3)

PO6: Communication Skills and Collaboration

- CO6: Present and manipulate textual information effectively. (Weightage: 2)
- CO7: Write well-structured and readable programs. (Weightage: 2)

PO7: Research-related Skills

- CO4: Apply logical reasoning in algorithm development. (Weightage: 2)
- CO5: Analyze structured datasets using appropriate techniques. (Weightage: 2)
- CO7: Design modular solutions supporting systematic problem-solving. (Weightage: 2)

PO8: Learning How to Learn Skills

- CO1: Independently set up and explore Python programming environment. (Weightage: 3)
- CO2–CO7: Adapt and apply programming concepts through self-learning. (Weightage: 2)

PO9: Digital and Technological Skills

- CO1: Demonstrate proficiency in programming environment usage. (Weightage: 3)
- CO2–CO7: Apply programming and data handling skills using appropriate tools. (Weightage: 3)

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- All COs contribute partially through collaborative programming practices. (Weightage: 1)

PO11: Value Inculcation and Environmental Awareness

- All COs contribute partially through ethical coding practices and responsible use of technology. (Weightage: 1)

PO12: Autonomy, Responsibility, and Accountability

- CO7: Develop independent programming projects and manage modular code. (Weightage: 3)
- CO1–CO5: Demonstrate accountability in logical problem-solving. (Weightage: 2)

PO13: Community Engagement and Service

- All COs contribute partially through application of programming for societal problem-solving. (Weightage: 1)

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2024 Pattern)

Name of the Programme : B.Sc. Statistics

Programme Code : USST

Class : T.Y.B.Sc.

Semester : V

Course Type : Major Elective (MJE) (Practical)

Course Code : STA-308-MJE(B)

Course Title : C - Programming

No. of Credits : 02

No. of Teaching Hours : 60

Course Objectives:

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:

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

CO 1. apply programming concepts to solve computational and real-world problems effectively.

CO 2. explore algorithmic approaches to problem solving.

CO 3. develop 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. understand 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. perform input and output operations using standard functions like printf and scanf.

List of Practical

Sr. No.	Title of Experiment
1.	Study of Structure of C Program and Demonstration of C Tokens, Data Types and Operators
2.	Formatted Input/output and Operator Precedence in C
3.	Implementation of Decision Making Statements (if, if-else, switch, conditional operator)
4.	Implementation of Loop Control Structures (while, do-while, for) with break and continue
5.	Program to Solve Mathematical Problems using Control Structures (Factorial, Fibonacci Series, Prime Number, Quadratic Equation, Interest Calculation)
6.	Program for One-Dimensional Array Operations (Sorting, Searching, Mean and Median of n Observations)
7.	Program to Compute Statistical Measures using Arrays (Variance, Standard Deviation, Coefficient of Variation)
8.	Program to Compute Correlation Coefficient and Regression Line for Bivariate Data
9.	Program for Matrix Operations using Two-Dimensional Arrays (Addition and Multiplication of Matrices)
10.	Program to Prepare Frequency Distribution from Raw Data
11.	Program to Compute Statistical Measures for Grouped Data (Mean, Variance, Standard Deviation, Quartiles)
12.	Implementation of String Handling Functions (strcpy(), strcat(), strlen(), strcmp(), strrev(), Array of Strings)
13.	Implementation of User Defined Functions (Call by Value and Call by Reference)
14.	Implementation of Recursive and Non-Recursive Functions (Factorial, Power Function, GCD, Maximum/Minimum of n Numbers)

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

Justification of CO-PO Mapping:

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 (2024 Pattern)

Name of the Programme	**:** B.Sc. Statistics
Programme Code	**:** USST
Class	**:** T.Y.B.Sc.
Semester	**:** V
Course Type	**:** On Job Training (OJT)
Course Code	**:** STA-309-OJT
Course Title	**:** On Job Training
No. of Credits	**:** 04
No. of Teaching Hours	**:** 120

Guideline of the Course:

As per Guideline prepared by College…

CBCS Syllabus as per NEP 2020 for T.Y.B.Sc. Statistics (2024 Pattern)

Name of the Programme : B.Sc. Statistics

Programme Code : USST

Class : T.Y.B.Sc

Semester : V

Course Type : Minor (Theory)

Course Code : STA-310-MN

Course Title : Statistical Inference

No. of Credits : 02

No. of Teaching Hours : 30

Course Objectives:

1. To understand the fundamentals of hypothesis testing.
2. To apply Z-tests for population means and proportions, both for one-sample and two-sample cases.
3. To understand how to construct confidence intervals for population means and proportions.
4. To apply t-tests for one-sample and two-sample means, and paired t-tests.
5. To understand the use of Chi-square tests for independence, goodness of fit.
6. To understand and apply tests based on the F-distribution to test hypotheses related to the equality of variances in two populations.
7. To understand the distinction between parametric and non-parametric tests.

Course Outcomes:

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

CO1 formulate and test statistical hypotheses, compute p-values, and interpret the results.

CO2 understand and apply the concepts of sampling distributions.

CO3 perform Z-tests for population means and proportions, compute and interpret.

CO4 conduct hypothesis tests using t-distributions and Chi-square tests, including testing for population means, variances.

CO5 perform hypothesis tests based on the F-distribution to assess the equality of variances between two populations

CO6 proficient in using non-parametric tests such as the Run test, Sign test, Median test, and Kolmogorov-Smirnov test.

CO7 interpret and communicate the results of statistical tests and confidence intervals clearly, making informed decisions based on data analysis in real-world applications..

Topics and Learning Points

Unit 1: Basic concept of Testing of Hypothesis and Sampling Distributions: (6 L)

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

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

1.3 Independence of $\bar{X}$ and S^2 (Statement only)

Unit 2: Large Sample Tests (Tests based on Normal distribution) : (6 L)

2.1 Z-tests for population means:

2.1.1 One sample and two sample tests for one-sided and two-sided alternatives

2.1.2 Confidence Interval for Population Mean:100(1- α)% two sided confidence interval for single population mean (μ) and difference of population means $(\mu_1 - \mu_2)$ of two independent normal populations.

2.2 Z-tests for population proportions:

2.2.1 One sample and two sample tests for one-sided and two-sided alternatives

2.2.2 Confidence Interval for Population Proportion: 100(1- α)% two sided confidence interval for single population proportion (P) and difference of population proportions $(P_1 - P_2)$ of two independent normal populations.

Unit 3: Small Sample Tests (Tests based on Normal distribution) : (10 L)

3.1. Tests based on Chi-square distribution:

3.1.1 Test for independence of two attributes

3.1.2 Test for Goodness of Fit (Without rounding off the expected frequencies)

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

3.2. Tests based on t-distribution: t-tests for population means:

3.2.1 One sample and two sample tests for one-sided and two-sided alternatives

3.2.2 Confidence Interval for Population Mean: 100(1- α) % two sided confidence interval for single population mean (μ) and difference of population means $(\mu_1 - \mu_2)$ of two independent normal populations.

3.3. Paired t-test for one-sided and two-sided alternatives.

3.4. 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 Tests **(8 L)**

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

4.2 Nonparametric Tests:

i) Run test one sample problems.

ii) Sign test

iii) Median test

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

References:

1. Goon A. M., Gupta, M. K. and Dasgupta, B. (1986), Fundamentals of Statistics.
2. Gupta, S. C. and Kapoor, V. K. (2002), Fundamentals of Mathematical Statistics, (Eleventh Edition), Sultan Chand and Sons.
3. Gupta, S. C. and Kapoor V. K. (2007), Fundamentals of Applied Statistics (Fourth Edition), Sultan Chand and Sons, New Delhi.
4. Gupta S. P. (2002), Statistical Methods (Thirty First Edition), Sultan Chand and Sons, 23, Daryaganj, New Delhi 110002.
5. Parimal Mukhopadhyaya: An Introduction to the Theory of Probability. World Scientific Publishing.
6. Hogg R.V. and Criag A.T.: Introduction to Mathematical Statistics (Third edition), Macmillan Publishing, New York.
7. Introduction to Probability Models, Sheldon M. Ross

Programme Outcomes and Course Outcomes Mapping:

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

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

CO–PO Mapping with Justifications

PO1: Comprehensive Knowledge and Understanding

- **CO1–CO6: (3)** – All these outcomes build deep theoretical understanding of statistical inference and distributions.
- **CO7: (3)** – Interpretation of results reflects conceptual clarity and overall understanding.

PO2: Practical, Professional, and Procedural Knowledge

- **CO1–CO6: (3)** – Performing Z, t, Chi-square, F, and non-parametric tests involves procedural competence used in professional data analysis.
- **CO7: (3)** – Communicating results for decision-making reflects professional practice.

PO3: Entrepreneurial Mindset and Knowledge

- **CO1, CO3, CO4, CO5, CO7: (2)** – Useful in market analysis, quality control, and business forecasting.
- **CO2, CO6: (1)** – Foundational/statistical techniques indirectly support entrepreneurship.

PO4: Specialized Skills and Competencies

- **CO1–CO6: (3)** – Directly develop specialized inferential statistical skills.
- **CO7: (3)** – Advanced competency in interpretation and reporting of results.

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

- **CO1–CO6: (3)** – Each test requires logical formulation, assumptions checking, and analytical interpretation.
- **CO7: (3)** – Informed decision-making strengthens analytical capacity.

PO6: Communication Skills and Collaboration

- **CO1–CO6: (2)** – Require explanation of results and reasoning.
- **CO7: (3)** – Explicit focus on communicating statistical conclusions clearly.

PO7: Research-related Skills

- **CO1–CO6: (3)** – Hypothesis testing and sampling distributions are central research tools.
- **CO7: (3)** – Interpretation and reporting are essential in research documentation.

PO8: Learning How to Learn Skills

- **CO1–CO6: (2)** – Encourage understanding of assumptions and selection of suitable techniques.
- **CO7: (2)** – Promotes reflective learning through interpretation.

PO9: Digital and Technological Skills

- **CO1–CO6: (2)** – Application may require use of statistical tools/software.
- **CO7: (2)** – Presentation of results often uses digital tools.

PO10: Multicultural Competence, Inclusive Spirit, and Empathy

- **CO1–CO6: (1)** – Indirect contribution through objective analysis.
- **CO7: (2)** – Clear communication of findings promotes informed inclusive decisions.

PO11: Value Inculcation and Environmental Awareness

- **CO1–CO6: (1)** – Ethical hypothesis testing and avoiding manipulation of results.
- **CO7: 2 (2)** – Responsible reporting aligns with value-based education.

PO12: Autonomy, Responsibility, and Accountability

- **CO1–CO6: (2)** – Require independent analytical work and accountability for conclusions.
- **CO7: (3)** – Responsible communication of statistical decisions.

PO13: Community Engagement and Service

- **CO1–CO6: (1)** – Indirect application in community data analysis.
- **CO7: (2)** – Interpretation of real-world data supports societal decision-making.