-St. Xavier's College (Autonomous), Ahmedabad
Syllabus of Semester – V of the following departments under Faculty of Science
based on Under Graduate Curriculum Framework – 2023 (NEP)
to be implemented from the Academic Year 2026-27.

FACULTY OF SCIENCE

DEPARTMENT OF STATISTICS

Course	Title	Content	Hours/week	Credit
STMC551C	**Sampling Distribution**	Unit 01: Chi-square Distribution Unit 02: Student's t-Distribution and Fisher's F-distribution Unit 03: Bivariate Normal Distribution Unit 04: Fisher's Z transformation and Order Statistics	4 hrs	4
STMC552C	**Statistical Inference**	Unit 01: Estimator and its properties Unit 02: Method of Estimation Unit 03: Testing of Hypothesis -I Unit 04: Testing of Hypothesis -II	4 hrs	4
STMC553L	**Statistics Practical - V**	Practical using manual calculation, R software and experiential learning	8 hrs	4
STMN551C	**Sampling techniques**	Unit 01: Stratified Random Sampling Unit 02: Systematic Sampling Unit 03: Two-Stage Sampling Unit 04: Practical based on Above units	6 hrs.	4
STSE551O	**Foundations of R software**	Swayam portal	4 hrs	2

BSc. Statistics

STMC551C Sampling Distribution

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course (Total - 04 Credit)			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Practical	Experiential Lab-1		
Sampling Distribution & STMC551C	4	0	0	10 + 2 from a recognized board in any stream	Basic Mathematics, Observation & Analytical Skills

Course Outcomes:

CO-1 Identify the Bivariate normal distribution and application in real - life studies and sustainability vales.

CO-2 Apply the Chi-square distributions and Pearson's coefficient of Chi-square distributions in real-life situations

CO-3 Apply the basic idea of Student's t- distribution and Fisher's F-distributions and their properties.

CO-4 Demonstrate the need of Order statistic and Fisher's Z distribution

Learning Outcomes: After completion of this course, the students will be able to

(1) Apply the *F*-distribution in the analysis of variance (ANOVA) and in comparing population variances.

(2) Implement the Chi-square distribution in tests for goodness-of-fit and independence in contingency tables.

(3) Apply the understanding of these distributions to solve real-world problems in various fields such as social sciences, biology, and engineering.

(4) Understand the Bivariate Normal distribution, its marginal and conditional distributions, and its relevance in statistical modeling.

Course Content:

Unit 1: Chi-square Distribution (15L)

- Definition and derivation of Chi-square distribution
- Mean and variance of Chi-square distribution
- Mode and skewness of Chi-square distribution
- Moment generating function and moments of Chi-square distribution
- Cumulant generating function, cumulants and central moments of Chi-square distribution
- Central MGF, Central moments and Pearson's coefficients of Chi-square distribution
- Additive property of Chi-square distribution

- Recurrence relation for central moments of Chi-square distribution
- Definition of sum and ratio of two independent chi-square variates
- The distributions of $\sum X_i^2$, $\sum X_i^2/n$, $\sqrt{\sum X_i^2}$, , $\sqrt{\sum X_i^2/n}$ for $X_i \sim iid\ N(0, \sigma^2)$
- Fisher's approximation of Chi-square distribution
- Applications of Chi-square distribution
- Examples of Chi-square distribution

Unit 2: Student's t-Distribution and Fisher's F-distribution (15L)

- Definition and Derivation of Fisher's t-distribution
- Derivation of student's t distribution
- Even and Odd ordered moments of t-distribution
- Approximation of t-distribution to Normal distribution
- Distribution of sample correlation-coefficient r
- Properties and examples of t-distribution
- Definition and Derivation of Snedecor's F-distribution
- Mean, mode and variance of F–distribution
- Relation between t and F distribution
- Relation between F and χ^2–distribution
- Applications and examples of F-distribution

Unit 3: Bivariate Normal Distribution (15L)

- Definitions of Bivariate Normal(BN) and Standard Bivariate Normal Distribution(SBND)
- Moment Generating Function of Bivariate Normal Distribution
- Marginal Distributions of X and Y
- Conditional Distributions of X|Y=y and Y|X=x
- M.G.F. and moments of BND and SBND
- Cumulant Generating Function and Cumulants of BND and SBND
- Examples of Bivariate Normal Distribution

Unit 4: Fisher's Z Distribution and Order Statistics (15L)

- Definition and Moment generation function of Z-distribution
- Fisher's Z-transformation
- Applications and Examples of Z-distribution
- Definition of Order Statistics
- Cumulative distribution function of a single Order statistic
- Probability density function of a single Order statistic
- Joint Probability density function of two Order statistics
- Joint Probability density function of k-Order statistics
- Joint Probability density function of all n-Order statistics
- Distribution of Range of Order statistics
- Examples of Order statistics

Teaching methodology: Apart from the conventional blackboard teaching, other modes of teaching that will be adopted are power points, group discussions, quizzes, class test, problem solving and assignments.

References:

1. Hogg, R.V. and Craig, A.T. (1972): Introduction to Mathematical Statistics, Amerind Pub. Co.
2. Mood, A. M. Greybill, F.A. and Bose, D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
3. Mukhopadhyay, P. (1999): Mathematical Statistics, New Central Book Agency.
4. Hoel, P.G. (1971): Introduction to Mathematical Statistics, Asia Pub. House.
5. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand publications.
6. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics Vol. I, World Press, Calcutta.
7. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand Publications.
8. Mathematical Statistics (VI Edition) - John E. Freund.

STMC552C Statistical Inference

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course (Total - 04 Credit)			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Practical	Experiential Lab		
Statistical Inference & STMC552C	4	0	0	10 + 2 from a recognized board in any stream	Basic Mathematics, Observation & Analytical Skills

Course Outcomes:

CO-1 Demonstrate the skills of parameter, parameter space, point and interval estimation.

CO-2 Apply the point estimators of population parameters by using the method of moments and MLE.

CO-3 Apply the foundations of hypothesis testing (most powerful test, N-P lemma, Applications)

CO-4 Demonstrate the testing of hypothesis (uniformly most powerful test, likelihood Ratio test)

Learning Outcomes: After completion of this course, the students will be able to

(1) Identify the characteristics of good estimators, such as unbiasedness, consistency, and efficiency.

(2) Derive point estimators for population parameters using methods like the Method of Moments and Maximum Likelihood Estimation (MLE).

(3) interpret calculate-values and make informed decisions based on hypothesis testing results.

(4) Apply estimation and hypothesis testing methods to solve real-world problems in various fields such as economics, biology, and engineering.

Unit-1 Estimator and its properties **(15L)**

- Notion of parameter, parameter space,
- General problem of estimating an unknown parameter by point estimation
- Concepts of statistic and estimator
- Property of unbiasedness
- Property of consistency
- Sufficient condition for consistency
- Property of efficiency
- Property of sufficiency
- Fisher- Neyman factorization theorem for sufficiency (for discrete random variable)

Unit-2 Method of Estimation **(15L)**

- Minimum Variance Unbiased estimator (MVUE) - definition and properties
- Cramer-Rao Inequality
- Method of maximum likelihood estimator
- Properties of maximum likelihood estimator
- Method of moments
- Method of confidence interval estimation

Unit-3 Testing of Hypothesis –I **(15L)**

- Concept of Statistical Hypothesis, Null and alternative hypotheses
- Types of error, level of significance, power of a test
- critical region, Unbiased test and unbiased critical region
- Best critical region
- Most powerful test
- Neymann-Pearson lemma
- Applications of NP Lemma

Unit-4 Testing of Hypothesis –II **(15L)**

- Uniformly most powerful test (for one –sided alternative hypothesis)
- Likelihood Ratio Test
- Properties of likelihood ratio test
- Applications of Likelihood Ratio Test

Teaching methodology: Apart from the conventional blackboard teaching, other modes of teaching that will be adopted are power points, group discussions, quizzes, class test, problem solving and assignments.

References:

1. Hogg, R.V. and Craig, A.T. (1972): Introduction to Mathematical Statistics, Amerind Publishing Co.
2. K.R. Koch (1987) : Parameter Estimation and Hypothesis Testing in Linear Models,
3. Mood, A.M., Greybill, F.A. and Bose, D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
4. Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency.
5. Rohtagi, V.K. (1967): An Introduction to Probability Theory and Mathematical Statistics,
6. John Wiley and Sons.
7. Dudewicz, E.J. and Mishra, S.N. (1988): Modern Mathematical Statistics, Wiley Series in Prob. Mathematical Statistics, John Wiley and Sons, New York (International Student Edition)
8. Goon, A.M., Gupta ,M. K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. I, WorldPress, Calcutta.
9. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
10. J. N. Kapoor, H. C. Saxena (1960): Mathematical Statistics, S. Chand & co.
11. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. II, WorldPress, Calcutta.

STMC553L Statistics Practical-V

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Practical	Activity / Case study analysis		
Statistics Practical-V & STMC553L	0	4	4	10 + 2 from a recognized board in any stream	Basic maths, Observation & Analytical Skills

Course Outcomes:

CO-1 Identify the need of stratification of the population associated with the problem under study and perform the stratification of a statistical population.

CO-2 Draw a stratified random sample from the population to estimate the unknown parameters of the population with their standard error.

CO-3 Demonstrate the need of drawing systematic sample from the population and compare its efficiency with simple random sampling and stratified random sampling.

CO-4 Apply the skill of drawing two stage sample (sub-sample) from the population and compare its efficiency with simple random sampling and stratified random sampling.

CO-5 Apply the skill of Small sample test in different data.

CO-6 Apply the Skill of drawing a random sample from Bivariate normal distribution

CO-7 Demonstrate the skills of solving problems arising in business, industry and social science by using graphical method, Simplex method, transport algorithm, Hungarian method

CO-8 Demonstrate the skills of solving problems Using MLE, MOM and different hypothesis testing

CO-9 Demonstrate the use of R software for achieving the course outcomes of CO-1 to CO-8.

Learning Outcomes: After completion of this course, the students will be able to

(1) Describe the properties of the Bivariate Normal distribution and analyze random samples drawn from it.

(2) Conduct Chi-square tests to assess goodness-of-fit, test for independence of attributes, and evaluate the homogeneity of correlation coefficients.

(3) Understand and distinguish between Type I and Type II errors, and compute the power of a test.

(4) Formulate and test statistical hypotheses using the Neyman-Pearson Lemma to identify the most powerful tests.

Course Content:

- Drawing a random sample from Bivariate Normal distribution
- Chi-square test to test the goodness of fit
- Chi-square test to test the independence of attributes for 2x2 contingency table
- Chi-square test to test the significance of difference of observed and expected frequencies.
- Chi-square test to test the independence of attributes for mXn contingency table
- Chi-square test to test the homogeneity of correlation coefficient.
- t-test of significance for single mean and confidence limits
- t- test to test the significance difference between two population means and pair t-test for difference of means
- t- test to test the significance of population correlation coefficient
- F-test for equality of population variances
- F- test for to test of significance multiple and partial correlation coefficient
- Z-test to test the significance of difference between observed value and hypothetical value of population correlation coefficients
- Z-test to test the significance of difference between two independent population correlation coefficients
- Method of maximum likelihood estimation
- Method of moments
- NP-lemma
- Most powerful tests
- Probabilities of Type – I and Type – II errors, Power curve
- Obtaining best critical region for MP test

STMN551C Sampling techniques

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course (Total - 04 Credit)			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Practical	Experiential Lab		
Sampling techniques & STMN551C	2	2	0	10 + 2 from a recognized board in any stream	Basic Mathematics, Observation & Analytical Skills

Course Outcomes:

CO-1 Identify the need of stratification of the population associated with the problem under study and perform the stratification of a statistical population.

CO-2 Draw a stratified random sample from the population to estimate the unknown parameters of the population with their standard error.

CO-3 Demonstrate the need of drawing systematic sample from the population and compare its efficiency with simple random sampling and stratified random sampling.

CO-4 Apply the skill of drawing two stage sample (sub-sample) from the population and compare its efficiency with simple random sampling and stratified random sampling.

Learning Outcomes: After completion of this course, the students will be able to

(1) To apply various sampling techniques, including simple random sampling, stratified sampling, systematic sampling, and two-stage sampling.

(2) Compute point estimates for population parameters such as the mean and proportion.

(3) Calculate standard errors associated with these estimates to assess their variability.

Course Content:

Unit-1: Stratified Random Sampling **(20L)**

- Introduction
- Notations and terminology
- Estimation of population mean, total and proportion standard errors and estimation of standard errors.
- Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
- Theoretical examples based on variances of sample mean under different allocations.
- Relative precision of stratified random sampling and simple random sampling
- Determination of sample sizes when (i)variance of stratified mean is known (ii) when total cost of sampling (C) is known.
- Stratified random sampling for proportions

- comparison between stratified sampling and simple random sampling.
- Merits and demerits of stratified random sampling
- Mixed examples based on stratified random sampling for variables and proportions

Unit-2: Systematic Sampling and Two Stage Sampling (25L)

- Systematic Sampling Introduction
- Estimation of population mean and standard error of the estimator
- Advantages and limitations
- Comparison of systematic sampling (N=nk) with SRSWOR and stratified sampling
- Two-Stage Sampling Introduction
- Finding means and variances in two-stage sampling (without proof)
- Variance of the estimated mean in two-stage sampling (without proof)
- Sample estimation of the variance (without proof)
- The estimation of proportions
- Optimum sampling and sub-sampling fractions

Unit-3: Practical based on topics (15L)

- Stratified Random sampling: Estimation of population mean and total, standard error of estimators and estimation of standard errors
- Stratified Random sampling: Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
- Stratified Random sampling: Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
- Stratified Random sampling: Relative precision of stratified random sampling and simple random sampling
- Systematic sampling: Estimation of population mean and standard error of the estimator
- Two-stage sampling: Estimation of population mean and standard error of the estimator

Teaching methodology: Apart from the conventional blackboard teaching, other modes of teaching that will be adopted are power points, group discussions, quizzes, class test, problem solving and assignments.

References:

1. Murthy.M.N : Sampling Theory and Methods, (Statistical Probability Society, Calcutta)
2. Cochran.W.G: Sampling Techniques (Wiley Eastern Ltd)
3. Desraj: Sampling Theory, (Tata Mc Graw Hill)
4. D.Singh and F.S.Chaudhary: Theory and Analysis of Sample survey, (JohnWileyand Sons)
5. Mukhopadhyay, P. (1998): Theory and Methods of Survey Sampling. Prentice Hall.
6. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. II, WorldPress, Calcutta.

7. Gupta, S.C., and Kapoor, V.K. : Fundamentals of Applied Statistics, Sultan Chand Publication.
8. Pathak, K.B. and Ram, F.: Techniques of demographic analysis- Himalaya Publishing house (1992).
9. Srivastva, O.S.:A text book of demography(1982).
10. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics Vol II, World Press, Calcutta.

STSE551O Foundations of R software

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course Title & Code	Credit Distribution of The Course (Total - 04 Credit)			Eligibility Criteria	Prerequisite(s) of the Course (if any)
	Lecture	Practical	Experiential Lab		
Foundations of R software & STSE551O	0	4	0	10 + 2 from a recognized board in any stream	Basic Mathematics, Observation & Analytical Skills

Course Outcomes:

CO-1 Demonstrate the skills to use data type and different function using R.
CO-2 Demonstrate the skills of diagrams using R-programming.
CO-3 Identify the need and application of measures of central tendency, dispersion, skewness and kurtosis using R-programming.
CO-4 Apply the skill of drawing various graphs using R- programming
Co-5 Apply the skill of draw and fit a probability distribution and test a hypothesis.

I. Course Content:

https://onlinecourses.nptel.ac.in/noc24_ma95/preview