St. Xavier's College (Autonomous), Ahmedabad-9
Proposed Syllabus: B.Sc. Statistics Semester V
Effective from June 2021

CORE Paper: Sampling Distribution
Course Code: ST5501
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

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

I. Course Overview & Course Objectives:
Unit 01: Chi-square Distribution
Unit 02: Student's t-Distribution and Fisher's F-distribution
Unit 03: Fisher's Z transformation and Order Statistics
Unit 04: Bivariate Normal Distribution

The main objective of this course is to introduce to the students the basic concepts of to introduce two important distributions namely the chi-square distribution and bivariate normal distribution. Along with these distributions introduce Student's t and Fisher's F distributions. By the end of this course students are expected to be able to derive the properties of the chi-square and bivariate normal distributions. They will also be able to apply t-distribution, F-distribution and Z-transformation to solve theoretical and practical problems arising in different branches of statistics.

II. 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: 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

Unit 4: 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

III. 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.

CORE Paper: Statistical Inference
Course Code: ST 5502
No. of Credits: 04
Learning Hours: 60 hours (70 marks)

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)

I. Course Overview & Course Objectives:

Unit 01: Estimator and its properties
Unit 02: Method of Estimation
Unit 03: Testing of Hypothesis -I
Unit 04: Testing of Hypothesis -II

The main objective of this course is to introduce to the students the basic concepts of the concepts of statistical inference, characteristics of good estimator and various methods of estimation. To introduce idea of statistical hypothesis and their testing. By the end of this course students are expected to be able to obtain point estimators of population parameters by using methods of moments, MLE etc. and derive their properties. They will also able to test the statistical hypothesis using NP Lemma and Likelihood ratio test

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

III. 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.

CORE Paper: Sampling techniques
Course Code: ST5503
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

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.

I. Course Overview & Course Objectives:
Unit 01: Stratified Random Sampling-I
Unit 02: Stratified Random Sampling-I
Unit 03: Systematic Sampling
Unit 04: Two-Stage Sampling

To discuss the procedures of various sampling methods, create estimates of population parameters and their standard errors. By the end of this course students are expected to be able to obtain estimates of population mean, proportion with their standard errors and construct the confidence intervals for these estimates.

II. Course Content:

Unit-1: Stratified Random Sampling-I (15L)

- 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.

Unit-2: Stratified Random Sampling-II (15L)

- 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-3: Systematic Sampling (15L)

- 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

Unit-4: Two-Stage Sampling (15L)

- Introduction
- Finding means and variances in two-stage sampling
- Variance of the estimated mean in two-stage sampling
- Sample estimation of the variance
- The estimation of proportions
- Optimum sampling and sub-sampling fractions

III. 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.

CORE Paper: Operations Research-I
Course Code: ST5504
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

Course Outcomes:
CO-1 Apply the skill of formulating and solving liner programming problems using graphical method.

CO-2 Demonstrate the skills of solving problems arising in business, industry and social science by using Simplex method.

CO-3 Apply the methods of solving transportation and assignment problems arising in business and industry.

CO-4 Demonstrate the skills of solving problems arising in business and industry by using Duality and sensitivity analysis in LP.

I. Course Overview & Course Objectives:
Unit 01: Operations Research and Linear Programming problems
Unit 02: Simplex Methods
Unit 03: Duality and Sensitivity Analysis in LP
Unit 04: Transportation Problems and Assignment Problems

To introduce quantitative techniques of linear programming problem, transportation problem, assignment problem, duality and sensitivity
analysis. Along with the methods of solutions of these problems. By the end of this course students are expected to be able to obtain optimum solution of the problems arising in business, industry, social science by using the method of graphical, simplex, Vogel's method, MODI method, Hungarian method.

II. Course Content:

Unit-1: Operations Research and Linear Programming problems (15L)

- Introduction of Operations Research
- Modelling in Operations Research
- General Methods for solving Operations Research Models
- Advantages of Operations Research study
- Introduction and Structure of LPP Model
- Advantages and Limitations of using Linear Programming
- General Mathematical Model of LPP
- Examples of LP Model formulation
- Introduction and Important definitions of Graphical Method
- LPP Solution using Graphical Method

Unit-2: simplex methods (15L)

- Introduction of artificial variables/slack/surplus variable
- Standard form of an LP problem
- Simplex Algorithm (Maximization case)
- Simplex Algorithm (Minimization case)
- Big – M method
- Two Phase method

Unit-3: Duality and Sensitivity Analysis in LP (15L)

- Concept of Duality
- Formulation of primal-dual pairs
- Duality Theorems
- Dual Simplex Algorithm
- Sensitivity Analysis-Change in Objective function coefficient
- Sensitivity Analysis-Change in Availability of resources
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Unit-4: Transportation Problems and Assignment Problems (15L)

- Introduction
- General Mathematical Model of TP
- The Transportation Algorithm (without proof)
- Methods of finding Initial solution
    1. North West Corner Rule
    2. Least Cost Method
    3. Vogel's Approximation Method
- MODI method of finding Optimum solution
- Variations in TP
    1. Unbalanced Supply and Demand

2. Degeneracy and its Resolution
3. Prohibited Transportation Routes
4. Maximization case in Transportation Problem

- Mathematical Model of Assignment Problem
- Optimum Solution of AP by Hungarian method
- Variations in AP
    1. Multiple Optimal Solutions
    2. Maximization case
    3. Unbalanced AP
    4. Prohibited AP

III. 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. J.K. Sharma (2007) : Operations Research: Theory and Applications, MacMillan India Pvt. Ltd.
2. Hillier, F.S. and Liebermann G.J. (1970): Introduction to Operations Research, Tata McGraw.Hill.
3. Gass, S.I. (1975) : Linear Programming, Methods and Applications, 4th Ed
4. Gross, D. and Harris, C.M.(1974): Fundamentals of Queueing Theory, John Wiley and Sons.
5. Sivazlian, B.D. and Stanfel, L.E.(1975): Analysis of Operations Research.
6. KantiSwarup, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
7. Taha, H.A. (1976) : Operational Research : An Introduction, 2nd Ed.
8. Philips, D.T., Ravindran, A. And Solberg, J. (1976): Operations Research, Principles and Practice.
9. Heardly, G. (1962) : Linear Programming

Elective Paper: Statistics Using R
Course Code: ST5401
No. of Credits: 03
Learning Hours: 30 hrs (70 marks)

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

I. Course Overview & Course Objectives:

Unit 01: Fundamentals of R
Unit 02: Introduction to graphical analysis
Unit 03: Descriptive statistics and tabulation

The main objective of this course is to introduce to the students the basic concepts of fundamentals of R, diagrams and Measures of Central Tendency, Dispersion, Skewness and Kurtosis. By the end of this course students are expected to be able to using basic R software in statistical data.

II. Course Content:

Unit-1: Fundamentals of R (10L)

- Introduction to R, features of R, installation of R, starting and ending R session, getting help in R, R commands and case sensitivity
- Data types: Logical, numeric and complex Vectors and vector arithmetic
- Creation of vectors using functions c, assign, seq, rep
- Arithmetic operations on vectors using operators +, -, *, /, ^.
- Numerical functions: log10, log, sort, max, min, unique, range, length, var, prod, sum, summary etc.
- Accessing vectors
- Alternative ways to create vectors by scan function
- Data frames: creation using data. Frame, subset and transform commands
- Resident data sets: Accession and summary

Unit-2: Introduction to graphical analysis (10L)

- Box plots
- Scatter plots
- Multiple correlation plots
- Line charts
- Pie charts
- Bar charts
- Dot charts
- Multiple series on one graph

Unit-3: Descriptive Statistics and tabulation (Using R) (10L)

- Mean, Mode, Median, Quartiles, Deciles, Percentiles, G.M and H.M.
- Dispersion: variance, standard deviation, coefficient of variation, mean deviation

- Skewness: Bowley's coefficient and Karl Pearson's coefficient of skewness
- Moments: Computations of raw and central moments, measure of skewness and kurtosis based on it.

III. 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. S.G. Purohit, S.D. Gore, S.R. Deshmukh : Statistics using R : Narosa Publishing.

Paper: Statistics Practical
Course Code: ST5505L
Credit:03
(Duration: 12 Hours per week)
Total Marks:70

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 Excel for achieving the course outcomes of CO-1 to CO-8.

I. Course Objectives:

The main objective of this course is to introduce to the students the basic concepts of random sample from Bivariate Normal distribution, chi-square test to test the goodness of fit, independence of attributes, homogeneity of correlation coefficient, MLE, MOM, most power full test, type-I type-II errors, stratified random sampling, systematic sampling, two-stage sampling, t-test, F-test, graphical method, Big-M method, transportation problem, duality. By the end of this course students are expected to be able to obtain a solution of the problems arising in business, industry, social science by using the above-mentioned methods.

II. Course Content:

Practical Paper-I

- 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

Practical Paper-II

- 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

Practical Paper-III

- Formulation of linear programming problem
- Graphical method for solving LPP
- Simplex method for Solving LPP
- Simplex method for Solving LPP
- Big-M method for LPP
- Two-Phase method for LPP
- Initial Basic feasible solution to a Transportation problem
- Finding optimum solution to a transportation problem
- Hungarian method for solving assignment problem
- Duality in LPP
- Sensitivity analysis in LPP

Practical Paper-IV (Using SPSS and Microsoft Excel)

- Drawing a random sample from Bivariate Normal distribution
- Application of Chi-square distribution to test the goodness of fit
- Application of Chi-square distribution to test the independence of attributes
- Application of t-distribution
- Application of F-distribution
- Application of Z-distribution

III. Teaching methodology: Apart from the conventional blackboard teaching, other modes of teaching that will be adopted are power points, computers.

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.
9. Murthy.M.N : Sampling Theory and Methods, (Statistical Probability Society, Calcutta)
10. Cochran.W.G: Sampling Techniques (Wiley Eastern Ltd)
11. Desraj: Sampling Theory, (Tata Mc Graw Hill)
12. D.Singh and F.S.Chaudhary: Theory and Analysis of Sample survey, (JohnWileyand Sons)
13. Mukhopadhyay, P. (1998): Theory and Methods of Survey Sampling. Prentice Hall.
14. J. K. Sharma (2007) : Operations Research: Theory and Applications, MacMillan India Pvt. Ltd.
15. Hillier, F.S. and Liebermann G.J. (1970): Introduction to Operations Research, Tata McGraw.Hill.
16. Gass, S.I. (1975) : Linear Programming, Methods and Applications, 4th Ed
17. Gross, D. and Harris, C.M.(1974): Fundamentals of Queueing Theory, John Wiley and Sons.
18. Sivazlian, B.D. and Stanfel, L.E.(1975): Analysis of Operations Research.
19. KantiSwarup, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
20. Taha, H.A. (1976) : Operational Research : An Introduction, 2nd Ed.

St. Xavier's College (Autonomous), Ahmedabad-9
Proposed Syllabus: B.Sc. Statistics Semester VI
Effective from December 2021

CORE Paper: Probability theory
Course Code: ST6501
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

Course Outcomes:
CO-1 Identify the Truncated Probability distribution and Truncated probability distributions in real - life studies and sustainability vales.

CO-2 Apply the characteristic function of different distributions in real-life problem.

CO-3 Demonstrate the skills of different probability inequality to find upper and lower bounds of probabilities of some events based on different distributions.

CO-4 Demonstrate the skills of convergence in probability using weak law of large numbers and central limit theorem.

I. Course Overview & Course Objectives:
Unit 01: Probability Inequalities
Unit 02: Weak Law of Large Numbers and Central Limit Theorem
Unit 03: Characteristic Function
Unit 04: Truncated Distributions

To discuss concepts truncated distributions, characteristic function, probability Inequalities. Along with these the weak law of large number and Chebychev's inequality are derived / discussed. By the end of this course students are expected to be able to obtain probability distribution of truncated distributions and to apply weak law of large number and Chebychev's inequality to solve theoretical and practical problems arising in different branches of statistics.
They will also learn to derive and use the characteristic function of different distributions.

II. Course Content:

Unit 1: Probability Inequalities (15L)

- Chebychev's inequality (for continuous random variable)
- Generalised form of Bienayme-Chebychev's inequality
- Examples of Chebychev's inequality
- Examples of generalised form of Chebychev's inequality
- Examples to find upper and lower bounds of probabilities of some events based on different Distributions

- Cauchy-Schawartz inequality
- Boole's inequality
- Jensen's inequality

Unit 2: Weak Law of Large Numbers and Central Limit Theorem (15L)

- Convergence in Probability
- Weak law of large numbers
- Condition for applying Weak law of large numbers
- Bernoulli's law of large numbers
- Examples of Weak law of large numbers
- Central limit theorems
    - Linderberg-Levy form of central limit theorem
    - Liapounoff form of central limit theorem (only statement)
    - Different particular cases of central limit theorem
- Applications of central limit theorem

Unit 3: Characteristic Function (15L)

- Definition and properties of characteristic function
- Effect of change of origin and scale on characteristic function
- Theorems of characteristic function
- Cumulant generating function and relation between moments and cumulants
- Examples of characteristic function and cumulant generating function
- Inversion theorem (Levy theorem) of characteristic function
- Uniqueness theorem of characteristic function
- Kendall's form of Inversion theorem
- Criterion to determine whether the distribution is discrete or continuous
- Characteristic function of Binomial, Poisson, Normal, Gamma and Chi-square distributions.
- Examples of uniqueness theorem

Unit 4: Truncated Distributions (15L)

- Definition of truncated distributions from left, right and both sides
- Binomial Distribution truncated at X=0 and its properties
- Poisson Distribution truncated at X=0 and its properties
- Standard Normal Distribution truncated from both sides and its properties
- Normal Distribution truncated from both sides and its properties

- Standard Cauchy Distribution truncated at both ends with relevant range of variation and its properties
- One variate Gamma distribution truncated at X=A from left and its pdf and expression for r^{th}moment about origin
- Derivation and definition of Geometric distribution truncated at X = a from left, mean, variance and expressions for its m.g.f. and c.g.f.
- Derivation and definition of Exponential distribution truncated at X = a from left, mean, variance and expressions for its m.g.f. and c.g.f.

III. 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.

CORE Paper: Designs of Experiment
Course Code: ST 6502
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

Course Outcomes:

CO-1 Identify the need of analysis of variance using one way classification and two-way classification.

CO-2 Apply the idea of design of experiment, demonstrate the skills of designing the experiments using CRD in real-life situations.

CO-3 Demonstrate the skills of designing the experiments using RBD, LSD in real-life situations.

CO-4 Identify the need of factorial experimentation with main and interaction effects, total and partial confounding design.

I. Course Overview & Course Objectives:

Unit 01: Analysis of Variance
Unit 02: Designs of Experiment-I
Unit 03: Designs of experiment-II
Unit 04: Factorial Experiment

The main objective of this course is to introduce to the students the basic concepts of the ANOVA and designs of experiments along with designs of experiments using RBD, LSD and factorial experiments. By the end of this course students are expected to be able to apply the technique of one way and two-way ANOVA along with use of CRD. They will also be able to analyse the problem of with the help of technique of various designs of experiments.

II. Course Content:

Unit-1 Analysis of Variance (15L)

- Introduction of analysis of variance
- Assumptions of ANOVA
- One-way classification
- Analysis of one-way classification
- Critical difference
- Two-way classification
- Analysis of two-way classification

Unit-2 Designs of Experiment-I (15L)

- Basic idea and terminology of design of experiment
- Principles of experimental design
- Completely Randomized Design
- Merits and demerits of CRD
- Analysis of CRD
- Post-hoc (HSD) test

Unit-3 Designs of experiment-II (15L)

- Layout of Randomized Block Design
- Merits and demerits of RBD
- Statistical analysis of RBD

- Estimation of missing observation/s and its analysis
- Layout of Latin square design
- Merits and demerits of LSD
- Statistical analysis of LSD
- Estimation of missing observation/s and its analysis
- Efficiencies of design.

Unit-4 Factorial Experiment (15L)

- Concept and need of factorial experiments
- Idea of terms – main and interaction effect, confounding – total and partial,
- Yates' Procedure and Yates' table
- 2^2 and 2^3 factorial experiment
- Main effects and interactions, their best estimates and testing the significance when underlying design is RBD
- Concept of confounding – Total and Partial Confounding
- Confounding in 2^3 factorial experiment

III. 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. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. II, WorldPress, Calcutta.
2. M.N. Das & N. Giri : Design of experiments, (Wiley Eastern Ltd)
3. Kempthorne :Design of Experiments,
4. Montgomery D.C. (1976): Design and Analysis of Experiments, John Wiley
5. Cochran W.G. & Cox G.M. (1957): Experimental Designs, John Wiley
6. Federer W.T. (1975): Experimental Designs – Theory and Application, Oxford & IBH
7. Mukhopadhyay P. (1999): Applied Statistics

CORE Paper: Statistical Quality Control
Course Code: ST6503
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

Course Outcomes:

CO-1 Reflect the skill of identifying the application of statistical quality control in industry.

CO-2 Apply the idea of 3-sigma limits in business and industry to solve the problems related to quality control via process control

CO-3 Extend the technique of 'process control' to 'product control' in the statistical quality control analysis and design acceptance sampling plans for attributes.

CO-4 Extend the technique of 'process control' to 'product control' in the statistical quality control analysis and design acceptance sampling plans for variables.

I. Course Overview & Course Objectives:

Unit 01: Statistical Quality Control-I
Unit 02: Statistical Quality Control-II
Unit 03: Acceptance Sampling plans for attributes
Unit 04: Acceptance Sampling plans for variables

The main objective of this course is to introduce to the students the basic concepts of discuss idea of statistical quality control and its applications. To expose the applicability of various acceptance sampling plans for attributes and variables. By the end of this course students are expected to understand preparation of control charts and understand the technique of 'process control' to 'product control' in the statistical quality control analysis and design various acceptance sampling plans.

II. Course Content:

Unit 1: Statistical Quality Control-I (15L)

- Introduction and importance of SQC.
- Chance and assignable causes of variation in quality.
- Determination of tolerance limits.
- Theory of runs and criteria for detecting lack of control in the process.
- Rational subgroups, natural tolerance of process and specification limits.

Unit 2: Statistical Quality Control-II (15L)

- Control charts for Variables.
- Construction of $\bar{X}$, R and S charts with their interpretations.
- OC function of $\bar{X}$ chart only.
- Control charts for attributes.
- Construction of p, np, c, u charts and their interpretations.

Unit-3: Acceptance Sampling plans for attributes (15L)

- Introduction of acceptance sampling
- Concepts of AQL, LTPD, Producer's risk and Consumer's risk,

- OC curve, AOQ, AOQL, ASN, ATI for SSP
- Construction of single sampling plan by fixing two points on the OC curve.
- Double sampling plan

Unit-4: Acceptance Sampling plans for variables (15L)

- Introduction of acceptance sampling plans for variables
- Advantages and disadvantages of sampling plans for variables compared to sampling inspection plans for attributes
- Design of acceptance sampling plans for variable when LCL is specified and
    1. σ is known
    2. σ is unknown
- Design of acceptance sampling plans for variable when UCL is specified and
    1. σ is known
    2. σ is unknown

III. 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. Mukhopadhyay, P.: Applied Statistics, New Central Book Agency(1999)
2. Montgomery, D.C. (2001): Introduction to Statistical Quality Control, Wiley.
3. Grant, E.L. (2000) : Statistical Quality Control, 7th Ed., Tata Mcgraw Hill
4. Ott, E.R. (1975) : Process Quality Control, McGraw Hill.
5. Wetherill, G.B. (1977) : Sampling Inspection and Quality Control, Halsted Press.
6. Wetherill, G.B. and Brown, D.W. : Statistical Process Control, Theory and Practice, Chapman and Hall.

CORE Paper: Operations Research-II
Course Code: ST6504
No. of Credits: 04
Learning Hours: 60 hrs (70 marks)

Course Outcomes:

CO-1 Demonstrate the skills of solving problems arising in business and industry by using PERT-CPM.

CO-2 Demonstrate the skills of solving problems arising in business and industry by using inventory models.

CO-3 Apply the skill of simulation in different methods.

CO-4 Demonstrate the need of identifying ‘game theory’ like situation, construct pay-off matrix and find optimum strategies rusting in best inserts of players/competitors.

I. Course Overview & Course Objectives:

Unit 01: PERT-CPM
Unit 02: Inventory Theory
Unit 03: Simulation
Unit 04: Game Theory

To discuss the concepts of, PERT-CPM, Simulation, Game theory and inventory modelling. To expose the applicability of these quantitative techniques in different disciplines. By the end of this course students are expected to be able to obtain a solution of the problems arising in business, industry, social science by using the above-mentioned methods.

II. Course Content:

Unit-1: PERT-CPM (15L)

- Introduction
- Basic difference between PERT and CPM
- Significance of using PERT and CPM
- Network Components and Precedence Relationships
- Critical Path Analysis
    1. Forward Pass Method
    2. Backward Pass Method
    3. Float of an activity
    4. Critical Path
- Project Scheduling with uncertain activity times

Unit-2:Inventory theory (15L)

- Introduction
- Meaning of Inventory Control
- Function Role of Inventory
- Reasons for carrying Inventory
- Factors involved in Inventory Problem Analysis
    1. Relevant Inventory cost
    2. Demand for Inventory items
    3. Replenishment lead time
    4. Length of planning period
    5. Constraint on the Inventory system
- Inventory Model building
- Single item Inventory control models without shortages
    1. EOQ Model with Constant Rates of Demand
    2. EOQ Model with Different Rates of Demand

3. EPQ Model When Supply (Replenishment) is Gradual

- Single item Inventory control models with shortages
    1. EOQ Model with Constant Demand and Variable Order Cycle Time
    2. EOQ Model with Different Demand and Fixed Reorder Cycle Time
    3. EOQ Model with Gradual Supply and Shortage Allowed

Unit-3: Simulation **(15L)**

- Introduction and definition
- Types of Simulation
- Steps of Simulation Process
- Stochastic Simulation and Random Numbers
- Monte Carlo Simulation
- Random Number Generation
- Simulation of PERT problems
- Simulation of Inventory Problems
- Simulation of Investment Problems
- Simulation of Maintenance Problems
- Advantages and Disadvantages of Simulation

Unit-4: Game Theory **(15L)**

- Introduction
- Two-Person Zero Sum Game
- Pure Strategies: Game with Saddle Point
- Mixed Strategies: Game without Saddle Point
- Dominance Property
- Solution for Games without Saddle Point by Algebraic Method

III. 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. J. K. Sharma (2007) : Operations Research: Theory and Applications, MacMillan India Pvt. Ltd.
2. Hillier, F.S. and Liebermann G.J. (1970): Introduction to Operations Research, Tata McGraw.Hill.
3. Gass, S.I. (1975) : Linear Programming, Methods and Applications, 4th Ed
4. Gross, D. and Harris, C.M.(1974): Fundamentals of Queueing Theory, John Wiley and Sons.
5. Sivazlian, B.D. and Stanfel, L.E.(1975): Analysis of Operations Research.

6. KantiSwarup, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
7. Taha, H.A. (1976) : Operational Research : An Introduction, 2nd Ed.
8. Philips, D.T., Ravindran, A. And Solberg, J. (1976): Operations Research, Principles and Practice.
9. Heardly, G. (1962) : Linear Programming
10. Gibbons, J.D. (1985): Nonparametric Statistical Inference, 2nd ed., Marcel Dekker, Inc.
11. Randles, R.H. and Wolfe, D.A. (1979) Introduction to the Theory of Nonparametric Statistics, John Wiley and Sons, Inc.
12. Hajek, J. and Sidak, Z. (1967) : Theory of Rank Tests, Academic Press.
13. Siegel S.: Non Parametric Methods for the Behavioral Sciences. International
14. Student Ed. McGraw Hill Kogakusha Ltd.

Elective Paper: Advanced R- programming
Course Code: ST6401
No. of Credits: 03
Learning Hours: 30 hrs (70 marks)

Course Outcomes:
CO-1 Demonstrate the skill of fitting of different distribution using R-programming.

CO-2 Demonstrate the skill of fitting of lines of regression using R-programming.

CO-3 Identify the need and application of correlation coefficient, multiple regression using R-programming.

CO-4 Apply the skill of simple hypothesis testing using R- programming.

I. Course Overview & Course Objectives:
Unit 01**:** Data: Distribution
Unit 02: Simple hypothesis testing
Unit 03: Regression (Linear modeling)

The main objective of this course is to introduce to the students the advance concepts of R programming. To expose the applicability of simple hypothesis testing and regression. By the end of this course students are expected to be able to using R software in testing using different hypothesis test and regression in liner, Multiple, Curvilinear data.

II. Course Content:

Unit-1: Data: Distribution **(10L)**

- Binomial distribution
- Poisson distribution
- Normal distribution
- Random number generation and control
- Random numbers and sampling
- Test for normality

Unit-2: Simple hypothesis testing **(10L)**

- Student's t-test
- Wilcoxon U-test
- Correlation and covariance
- Tests for association

Unit-3: Regression (Linear modeling)
(10L)

- Simple linear regression
- Multiple regression
- Curvilinear regression
- Plotting linear models and curve fitting

III. 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.S.G. Purohit, S.D. Gore, S.R. Deshmukh : Statistics using R : Narosa Publishing.

Paper: Statistics Practical
Course Code: ST6505L
Credit:03
(Duration: 12 Hours per week)
Total Marks: 70

Course Outcomes:

CO-1 Demonstrate the skill of fitting of truncated distributions such as Binomial, Poisson to real-life data.

CO-2 Reflect the skill of drawing random samples from truncated distributions.

CO-3 To design the experiment using CRD, RBD, LSD and factorial

CO-4 Reflect the skill of one-way and two-way classification.

CO-5 Demonstrate the skills of solving problems arising in business, industry and social science by using PERT-CPM and Inventory theory.

CO-6 Demonstrate the need of identifying 'game theory' like situation, construct pay-off matrix and find optimum strategies rusting in best inserts of players/competitors.

CO-7 Demonstrate the use of R-programming for achieving the course outcomes of CO-1 to CO-4

I. Course Objectives:

The main objective of this course is to introduce to the students the basic concepts of Fitting and random sample of Truncated Binomial and Poisson Distributions. One-way and two-way classification Randomized block design, 2^2 and 2^3 factorial experiment, PERT diagram, Critical path method, inventory theory and game theory. By the end of this course students are expected to be able to obtain a solution of the problems arising in business, industry, social science by using the above mentioned methods.

II. Course Content:

Practical Paper-I

- Fitting of Truncated Binomial Distributions
- Fitting of Truncated Poisson Distributions
- Drawing a random sample from Truncated Binomial Distributions
- Drawing a random sample from Truncated Poisson Distributions
- One-way classification
- Two-way classification
- Completely Randomized Design
- Randomized Block Design
- Estimation of missing observations(one/Two) in RBD
- Latin Square Design
- Estimation of missing observations (one/Two)in LSD
- 2^2 factorial experiment
- 2^3 factorial experiment

- Total confounding in 2^3 factorial design
- Partial confounding in 2^3 factorial design

Practical Paper-II

- Construction of control charts for variable (Mean, range and standard deviation)
- Construction of control charts for attributes(p, np, c and u)
- Single sampling plan: AQL, LTPD, Producer's risk and Consumer's risk
- Single sampling plan : OC curve, AOQ, AOQL, ASN, ATI for SSP only
- Single sampling plan : OC curve, AOQ, AOQL, ASN, ATI for SSP only

Practical Paper-III

- Drawing of PERT diagram
- Estimation of Project completion time
- Estimation of Project completion time
- Critical Path method
- Inventory theory : Single item Inventory control models without shortages
- Inventory theory : Single item Inventory control models with shortages
- Simulation of PERT problems
- Simulation of Inventory Problems
- Simulation of Investment Problems
- Simulation of Maintenance Problems
- Practical based on Game theory

Practical Paper-IV (Using R and Microsoft Excel)

- Fitting of Truncated Binomial Distributions
- Fitting of Truncated Poisson Distributions
- Drawing a random sample from Truncated Binomial Distributions
- Drawing a random sample from Truncated Distributions
- One-way classification
- Two-way classification
- Completely Randomized Design
- Randomized Block Design
- Latin Square Design
- 2^2 factorial experiment
- 2^3 factorial experiment

III. Teaching methodology: Apart from the conventional blackboard teaching, other modes of teaching that will be adopted are power points, computers.

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.
9. Murthy.M.N : Sampling Theory and Methods, (Statistical Probability Society, Calcutta)
10. Cochran.W.G: Sampling Techniques (Wiley Eastern Ltd)
11. Desraj: Sampling Theory, (Tata Mc Graw Hill)
12. D.Singh and F.S.Chaudhary: Theory and Analysis of Sample survey, (JohnWileyand Sons)
13. Mukhopadhyay, P. (1998): Theory and Methods of Survey Sampling. Prentice Hall.
14. J. K. Sharma (2007) : Operations Research: Theory and Applications, MacMillan India Pvt. Ltd.
15. Hillier, F.S. and Liebermann G.J. (1970): Introduction to Operations Research, Tata McGraw.Hill.
16. Gass, S.I. (1975) : Linear Programming, Methods and Applications, 4th Ed
17. Gross, D. and Harris, C.M.(1974): Fundamentals of Queueing Theory, John Wiley and Sons.
18. Sivazlian, B.D. and Stanfel, L.E.(1975): Analysis of Operations Research.
19. KantiSwarup, Gupta, P.K. and Singh, M.M. (1985): Operations Research, Sultan Chand and Sons.
20. Taha, H.A. (1976) : Operational Research : An Introduction, 2nd Ed.