**St Xavier's College (Autonomous), Ahmedabad**
**Department of Statistics**
**B.Sc. Statistics**

**Semester I**
**CORE Paper: Mathematical Statistics-1**
**Course Code: ST1501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
The main objective of this course is to introduce to the students the basic concepts of probability, random variable, expectation, raw and central moments and least square method.

**Learning Outcomes:**
By the end of this course students are expected to be able to distinguish between random and non-random experiments, to find the probabilities of events, to fit various mathematical curves ( linear and non- linear) to observed data by using principle of least squares and forecasting values of unknown values of the variable.

**Unit-1: Probability Theory -1**
1. Random experiments, Trial, discrete and continuous Sample space
2. Definitions of equally likely, mutually exclusive and exhaustive events, Favorable cases
3. Definition of probability, classical and relative frequency approach to probability, axiomatic approach to probability and its properties. For example,
4. Proof of the inequalities for two events A and B
5. Applications of probability in various fields

**Unit-2: Probability Theory -2**
1. Conditional probability and its properties, Independence of two events, Pair wise and Mutual independence for three events and related theorems
2. Theorem on total probability and related examples
3. Bayes' theorem and its applications

**Unit-3: Curve Fitting**
1. Concept of Bivariate data, Plotting of Bivariate data,
2. Principle of Least Squares, fitting of Linear, Parabolic Exponential curves (reducible to linear)
3. Most plausible solutions

**Unit:4 Random Variable**
1. Types of Random variables ( Discrete and Continuous )
2. Probability mass function, probability density function and distribution function of discrete and continuous random variable.
3. Properties of distribution function and theorems.

4. Mathematical Expectation and its basic properties
5. Theorems on Mathematical Expectation
6. Raw and Central Moments and their recurrence relation

**References**


1. W. Feller: Introduction to the Theory of Probability and its Application (Wiley), Vols. 1,2.
2. K.L. Chung: Elementary Probability Theory.
3. S.M. Ross: A First Course in Probability.
4. R. Ash: Basic Probability Theory.
5. P.G. Hoel, S.C. Port and C. J. Stone: Introduction to Probability Theory.
6. J. Pitman: Probability. Narosa Publishing House.
7. Parzen , E. (1960): Modern Probability Theory and its Applications, Wiley Eastern.
8. Hogg, R.V.& Craig, A.T.: Introduction to mathematical Statistics,3rdedition – (collier – Mac Millan
9. KatheleenSubramaniam: A Primier in Probability ( Marcel – Dekken – 1970)
10. Agarwal, B. S. (1996): Basic Statistics ( 3rd Ed.) Newage International Publishers.
11. Goon, A.M. Gupta; M.K. and Das Gupt. B.: Fundamentals of Statistics, Vol. – 1 (1991) &Vol. 2 (2001), World Press – Calcutta.
12. Croxton, F.E. Cowden, D.J. & Klein, S.: Applied General Statistics (1973), Prentice Hall of India.
13. Agresthi A.: An Introduction to Categorical Data Analysis (1996), John Wiley and Sons Inc., N.Y.
14. Snedecor, G.W. and Cochran, W.G. – (1967): Statistical Methods, Iowa State University Press.
15. Spiegrl, M.R. (1967): Theory and Problems of Statistics – Schaum's Publishing Series.
16. Bhat, B.R. Srivenkatramana and Rao Madhava K.S. – Statistics: A beginner's Text Vol. I, New Age Internation (P) Ltd.
17. Mood, A.M., Gray bill, I.A. &Boes, D.C.Introduction to the theory of Statistics. 3rd Edition. – Tata McGraw Hill.
18. Kenny, J.F. and Keeping, E.S.Mathematical and Statistics – Vol. – II
19. Medhi, J.: Statistical Methods – An Introductory Text, (Wiley Eastern)


**Statistics Practical**
**Course Code: ST1502L**
**No. of Credits: 03**
**Learning Hours: 60 hrs**

**Part A: Manual Calculation**
**(Duration: 2 Hours per week)**
**Practicals are to be based on following topics:**

Pr.1 Presentation of Data.
Pr.2 Diagrams and Graphs.
Pr.3 Measures of Central tendency.
Pr.4 Measures of Dispersion.
Pr.5 Measure of Skewness.
Pr.6 Measure of Kurtosis.

**Part B: Using Microsoft Excel**
**(Duration: 2 Hours per week)**

Pr.1 Diagrams and Graphs.
Pr.2 Measures of Central tendency for ungrouped data.
Pr.3 Measure of Dispersion for ungrouped data.
Pr.4 Fitting of Straight line.
Pr.5 Fitting of Second degree parabola.
Pr.6 Fitting of Exponential and Power curve.

**Semester I**
**Elective**
**Course Code: EG 1301 Descriptive Statistics**
**No. of Credits: 02**
**Learning Hours: 30 hrs**

**Unit-1: Types of dada, Classification and Graphs & Diagrams**

1. Types of data – Primary and secondary data, qualitative and quantitative, nominal, ordinal, interval and ratio scale data
2. Classification of data
3. Representation of statistical data by
   a. Histogram
   b. Frequency Polygon
   c. Frequency Curve and Cumulative Frequency Curves of less than and more than type (Ogive curves)
4. To obtain median, mode, quartiles, deciles, percentiles, from the above graphs and simple examples.

**Unit-2: Measures of Central Tendency**

1. Meaning of central tendency.
2. Various measures of central tendency: arithmetic mean ,median, mode, their merits and demerits.
3. Simple examples of Mean, Median and Mode.
4. Positional Measures of central tendency: Quartiles, deciles, percentiles. their merits and demerits, Simple examples

**Unit-3: Measures of Dispersion**

1. Definition of dispersion.
2. Measures of dispersion.
3. Simple examples to find various measures of dispersion by different methods (Range, Q.D., M.D., S.D) for grouped and ungrouped data.

**Unit:4 Skewness and Kurtosis**

1. Meaning of Skewness.
2. Tests of skewness, Measures of Skewness.
3. Karl Pearson's and Bowley's method to measure the skewness.

4. Meaning of kurtosis, Measures

**References**


1. S.C. Gupta and V.K. Kapoor (2010) Fundamentals of Mathematical Statistics ,, S. Chand Publications (15th Edition)
2. Agarwal, B. S. (1996): Basic Statistics ( 3rd Ed.) Newage International Publishers.
3. Goon, A.M. Gupta; M.K. and Das Gupt. B.: Fundamentals of Statistics, Vol. – 1 (1991)


**B. Sc. Semester-II**
**CORE Paper: Mathematical Statistics-1I**
**Course Code: ST 2501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Prerequisites:** Concept of probability, random variable, probability distribution of random variable. Principle of least squares and fitting of straight line, mathematical expectation and its properties, moments.

**Objectives:** The main objective of this course is to introduce to the students the basic concepts of generating functions and bivariate distributions. Also, students will be introduced concept of correlation and regression for bivariate and tri-variate distribution moments and least square method.

**Learning Outcomes:** By the end of this course students are expected to be able to find PGF, MGF and moments of a given probability distribution. Students are also expected to interpret coefficient of correlation and fitting of regression line.

**Unit-1: Generating Functions**
1. Probability Generating Function (PGF)
2. Moment Generating Function (MGF)
3. Cumulant Generating Function (CGF).
4. Interrelations between Cumulants and Moments.

**Unit-2: Bivariate distributions**
1. Concept of Joint Distribution, Joint Mass Function.
2. Bivariate distribution, Marginal and Conditional Distribution
3. Independence of Random Variables.
4. Concept of Conditional Expectation and Conditional Variance (for discrete and continuous random variable) and related theorems.

**Unit-3: Correlation and Regression**
1. Concept of Bivariate data, Correlation Coefficient, Scatter diagram
2. Karl Pearson's correlation coefficient, Independence of variables
3. Limits for correlation coefficient
4. Spearman's Rank correlation coefficient
5. Coefficient of Determination and Probable Error.

6. Concept of Regression for two variables
7. Lines of regression, properties of regression coefficient, regression curve
8. Angles between two regression lines

**Unit-4: Regression, Multiple and Partial Correlation**

1. Regression and correlation in three variables.
2. Yule's notations, plane of regression
3. Properties of Residuals
4. Multiple and Partial Correlation coefficient and their interrelationships

**References:**


1. Hogg, R.V.& Craig, A.T.: Introduction to mathematical Statistics, 3rd edition – (collier – Mac Millan)
2. KatheleenSubramaniam: A Primier in Probability ( Marcel – Dekken – 1970)
3. Agarwal, B. S. (1996): Basic Statistics ( 3rd Ed.) Newage International Publishers.
4. Goon, A.M. Gupta; M.K. and DasGupta. B.: Fundamentals of Statistics, Vol. – 1 (1991) & Vol. 2 (2001), World Press – Calcutta.
5. Croxton, F.E. Cowden, D.J. & Klein, S.: Applied General Statistics (1973), Prentice Hall of India.
6. Agresthi A.: An Introduction to Categorical Data Analysis (1996), John Wiley and Sons Inc., N.Y.
7. Snedecor, G.W. and Cochran,W.G.–(1967): Statistical Methods, Iowa State University Press.
8. Spiegrl, M.R. (1967): Theory and Problems of Statistics – Schaum's Publishing Series.
9. Bhat, B.R. Srivenkatramana and Rao Madhava K.S. – Statistics: A beginner's Text Vol. I, New Age Internation (P) Ltd.
10. Mood, A.M., Gray bill, I.A. &Boes, D.C.
11. Introduction to the theory of Statistics. 3rd Edition. – Tata McGraw Hill.
12. Kenny, J.F. and Keeping, E.S.Mathematical and Statistics – Vol. – II
13. Medhi, J.: Statistical Methods – An Introductory Text, (Wiley Eastern)


**Statistics Practical**
**Course Code: ST 2502L**
**No. of Credits: 03**
**Learning Hours: 60 hrs**

**Part A: Manual Calculation**

**Practicals are to be based on following topics:**

Pr.1 Application problems on generating functions
Pr.2 Problems on bivariate probability distribution.
Pr.3 Karl-Pearson's Product moment correlation coefficient
Pr.4 Spearman's rank correlation coefficient
Pr.5 Fitting of line of regression
Pr.6 Plane of regression
Pr. 7 Multiple and Partial correlation coefficient

**Part B: Using Microsoft Excel**

**(Duration: 2 Hours per week)**
Pr.1 Karl Pearson's Correlation coefficient.
Pr. 2 Spearman's rank correlation coefficient.
Pr.3 Regression in two variables.
Pr. 4 Regression in three variables.
Pr. 5 Multiple correlation coefficient.
Pr. 6 Partial correlation coefficient.
Pr.7 Problems on bivariate probability distribution.

**Elective Course:**
**Environmental Science**

**Reference Website**
1. www.freestatistics.tk
2. www.psychstat.smsu.edu/sbk00.htm
3. www.bmj.bmjournals.com/collections/statsbk/index.shtml
4. www.statweb.calpoly.edu/bchance/stat-staff.html
5. www.amstat.org/publications/jse/jse-data-archive.html
6. www.statpages.org (WebPages that perform Statistical calculations)
7. www.amstat.org/publications/chance (Chance magazine)
8. www.statsci.org/datasets.html (Data sets)

**B.Sc. Semester-III**
**CORE Paper: Probability Distribution Theory-1**
**Course Code: ST 3501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To discuss various univariate distributions. To expose the applicability of various distributions in different disciplines.

**Learning Outcomes:**
By the end of this course students are expected to be able to obtain a probability distribution of random variable (univariate case) in the given situation and to apply standard discrete probability distribution to different situations.

**Unit-1: Binomial Distribution and Bernoulli Distribution**
1. Definition , $r^{th}$ moments about origin , mean and variance of Bernoulli Distribution.
2. Derivation and definition, basic properties of this distribution – factorial moments, mean, median, mode, variance.
3. Moment generating function and moments, recurrence relation for central Moments and moments about origin.
4. Cumulant generating function and cumulants, recurrence relation for cumulants.
5. Distribution of sum of independent binomial variates.
6. Applications and examples of this distribution.

**Unit-2: Poisson, Hyper Geometric Distribution**

1. Derivation and definition, basic properties of Poisson and Hyper geometric distributions – factorial moments, mean, median, mode, variance.
2. Moment generating function and moments, recurrence relation for central moments and moments about origin.
3. Cumulant generating function and cumulants.
4. Distribution of sum of independent Poisson variates.
5. Applications and examples of these distributions.

**Unit-3: Normal Distribution and Log Normal Distribution**

1. Definition, basic properties of normal and log normal distributions – mean, median, mode, variance.
2. Moment generating function and moments, Central moment generating function and central moments.
3. Cumulants generating function and cumulants.
4. Mean deviation from mean, recurrence relation for central moments.
5. Distribution of linear combination of independent normal variates.
6. Applications and examples of these distributions.

**Unit 4: Rectangular (Uniform) & Exponential Distribution**

1. Derivation and definition, basic properties of these distributions – mean, mode, variance.
2. Moment generating function and moments.
3. Cumulants generating function and cumulants, mean deviation from mean.
4. Distribution of sum of independent exponential variates.
5. Applications and examples of these distributions.

**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. (1996): Mathematical Statistics, New Central Book Agency.
4. Rohtagi, V.K. (1967): An Introduction to Probability Theory and Mathematical Statistics, John Wiley and Sons.
5. Hoel, P.G. (1971): Introduction to Mathematical Statistics, Asia Pub. House.
6. Meyer, P.L. (1970): Introductory Probability ands statistical Applications, Addison Wesley.
7. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Mathematical Statistics, Sultan Chand publications.
8. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. I, World Press, Calcutta.
9. A First Course in Probability - Sheldon. M. Ross, (Mc Millian publishing Co.).
10. Introduction to Probability and Statistics for Engineers and Scientists- S.M. Ross (Elsever).
11. A First course in Probability - T.Chandra &D. Chatterjee (Narosa Pub. House)
12. Mathematical Statistics (VI Edition) - John E. Freund.

**CORE Paper: Statistical Methods-1**
**Course Code: ST 3502**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To discuss hypothesis testing for large sample and non parametric tests. to introduce official statistics and basic sampling method.

**Learning Outcomes***:*
By the end of this course students are expected to be able to apply parametric and non parametric tests in different real life data. Students will come to know about premium statistics institutes functioning in India. They will get ideas about how to design a sample survey.

**Unit-1: Introduction to Hypothesis Testing and Large Sample Tests**
1. Basic idea of statistical inference and sampling distribution
2. Concept and elementary idea of statistical hypothesis, null and alternative hypothesis, level of significance, degree of freedom.
3. Z – test to test the significance of mean based on a large sample.
4. Test the significance of the difference between two sample means based on large sample.
5. Test of Proportions: To test the significance of single proportion based on a large sample, to test the significance of difference between two proportions based on large sample.
6. Fisher's Information and its use to test the significance of coefficient of correlation.

**Unit-2: Non-Parametric Tests**
1. Basic idea of non-parametric inference
2. Concept of a non – parametric tests.
3. Difference between parametric and non–parametric tests.
4. Sign test for on sample.
5. Wilcoxon signed rank test.
6. Mann – Whitney U – test.
7. Run test.
8. Median test.
9. Application based examples on non-parametric tests.

**Unit-3: Official Statistics and Sample Survey**
1. Concept of complete enumeration and sample survey.
2. Difference between census and survey.
3. Importance of sample survey.
4. Principal steps in sample survey.
5. Sampling and non-sampling errors.
6. Origin and functions of -National Sample Survey Organization (NSSO).
7. Central Statistical Organization (CSO), Indian Statistical Institute (ISI).
8. Indian Council for Medical Researches (ICMR) etc.

**Unit-4: Simple Random Sampling**

1. Probability of selecting any specified unit in the sample.
2. Selection of Simple Random Sample.
3. Merits and drawbacks of Simple Random Sampling.
4. Simple Random Sampling of Attributes.
5. Estimation of population mean and variance
6. Size of Simple Random Sample for specified precision.

**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, Mc Graw Hill.
3. Mukhopadhyay, P. (1996): 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. Sampling Theory and Methods - Murthy. M.N(Statistical Prob. Society, Cal).
10. Sampling Techniques -Cochran. W.G (Wiley Eastern Ltd).
11. Theory and Analysis of Sample survey - D. Singh and F. S. Chaudhary (John Wiley and Sons).


**Statistics Practical**
**Course Code: ST 3503L**
**No. of Credits: 03**
**Learning Hours: 60 hrs**

**Part A: Manual Calculation (Duration: 3 Hours per week)**

**Practicals are to be based on following topics:**

Pr. 1. Non-Parametric tests (Run test, Median test, Sign test, Sign-Ranked test).
Pr. 2. Fitting of Binomial distribution.
Pr. 3. Fitting of Poisson distribution.
Pr. 4. Fitting of Normal distribution.
Pr. 5. Generation of random sample from Binomial and Poisson distribution. (using random number table)
Pr. 6. Generation of random sample from Normal distribution.(using random number table)
Pr. 7. Generation of random sample from Rectangular and Exponential distribution. (using random number table)
Pr. 8. Simple random sampling.

**Part B: Using Microsoft Excel (Duration: 3 Hours per week)**

Pr. 1 Large sample tests for variables.
Pr. 2 Large sample tests for attributes.
Pr. 3 Fitting of Normal distribution.
Pr. 4 Fitting of Binomial distribution.
Pr. 5 Fitting of Poisson distribution.
Pr. 6 Generation of random sample from Binomial and Poisson distribution.
Pr. 7 Generation of random sample from Normal distribution.
Pr. 8 Generation of random sample from Rectangular and Exponential distribution.

**B.Sc. Semester – III**
**Elective Course**
**Course Code: EG 3301 Economic Statistics-I**
**No. of Credits: 02**
**Learning Hours: 30 hrs**

**Unit-1: Demand & Supply**

1. Ideas of demand and supply laws
2. Demand and supply functions(Curves)
3. Market Equilibrium
4. Revenue.

**Unit-2: Price Elasticity**

1. Concept of price elasticity of demand and supply
2. Interpretations of their values
3. Simple Examples

**Unit-3: Monopoly**

1. Idea of Monopoly
2. Maximization of profit under monopoly Simple Examples.

**Unit-4: Utility**

1. Concept of total utility and marginal utility
2. Maximization of utility
3. Examples

**References:**


1. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand Publications
2. R. G. D. Allen: Mathematical Analysis for Economists , Mc Milan and co. limited
3. R. G. D. Allen: Statistics for Economists , Mc Milan and co. limited


**Reference Website:**

1. www.sxca.edu.in
2. www.statsci.org/datasets.html (Data sets)

3. www.math.uah.edu/stat (Virtual laboratories in Statistics)
4. www.stat.ucla.edu/cases (Case studies in Statistics)
5. www.bmj.bmjournals.com (Excel data and Statistical Analysis)
6. www.psychstat.missouristate.edu (Introductory Statistics & Multivariate Statistics: Concepts, Models and Applications)
7. www.statpages.org (Web Pages that perform Statistical calculations)
8. www.amstat.org/publications/jse/jse-data-archive.html (Research Journals, magazines)
9. www.amstat.org/publications/chance (Chance magazine)
10. www.amstat.org/publications/stats (STATS: the magazine for students of Statistics)
11. www.freestatistics.org (for online software and search)

**Semester-IV**
**CORE Paper: Probability Distribution Theory -2**
**Course Code: ST4501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To discuss various continuous distributions. To expose the applicability of various distributions in different disciplines.

**Learning Outcomes:**
By the end of this course students are expected to be able to obtain a probability distribution of random variable in the given situation and to apply standard continuous probability distribution to different situations.

**Unit-1: Negative Binomial Distribution (Blaise Pascal's distribution) and Geometric Distribution**
1. Derivation and definition,
2. Polya's distribution as a particular case of negative binomial distribution
3. Basic properties of these distributions – Mean, Variance
4. Moment generating function and moments
5. Cumulants generating function and cumulants
6. Lack memory property of geometric distribution
7. Prob. Generating function of negative binomial distribution
8. Poisson distribution as a limiting case of negative binomial distribution
9. Applications and examples of these distributions.

**Unit-2: Gamma Distribution, Beta type I and Beta type II Distribution**
1. Derivation, basic properties of Gamma distribution, Beta type I and Beta type II distributions – Mean, mode, Variance, hyper geometric mean.
2. Additive property of Gamma distribution.
3. Moment generating function and moments.
4. Cumulant generating function and cumulants.
5. Distribution of ratio of two independent gamma variates with one parameters.

6. If X and Y are two independent gamma variates with one parameter then the derivation of distribution of X+Y, $\frac{X}{Y}$ , $\frac{X}{X+Y}$ .
7. Applications and examples of these distributions.

**Unit-3: Weibull, Cauchy, Laplace Distribution**

1. Definition and distribution function of Weibull distribution with two and three parameters.
2. $r^{th}$ moment about origin/some point, mean , mode and variance of Weibull distribution with two and three parameters.
3. Definition and characteristic function of standard Cauchy and Cauchy distribution with two parameters.
4. Additive property of independent Cauchy variates.
5. Distribution of mean of an independent sample from standard Cauchy distribution.
6. Distribution of product of two independent standard Cauchy variates.
7. Derivation of Cauchy distribution as a ration of two independent standard normal variates.
8. Distribution of square of standard Cauchy variate.
9. Definition , characteristic function , mean and variance of standard Laplace Distribution.
10. Definition, $r^{th}$ moment about origin , mean , and variance of Laplace distribution with two parameters.
11. Applications and examples of these distributions.

**Unit-4: Power Series and Compound Distribution**

1. Concept and definition of Power Series distribution.
2. Mean , variance , moment generating function , characteristic function of Power Series distribution.
3. Recurrence relation between the raw moments of Power Series distribution.
4. Recurrence relation between the central moments of Power Series distribution.
5. Recurrence relation between the cumulants moments of Power Series distribution.
6. Recurrence relation between the factorial cumulants moments of Power Series distribution.
7. Special cases of Power Series distribution.
   a. Binomial distribution
   b. Poisson distribution
   c. Geometric distribution
   d. Negative Binomial distribution
   e. Logarithmic series distribution
8. Unique determination of Power Series distribution from the first moments.
9. Concept and definition of compound distribution(unconditional distribution)
10. Negative binomial distribution as a compound distribution of Poisson and Gamma / Chi-square distributions.
11. T- distribution as a compound distribution of Normal and Gamma distributions.
12. Poisson distribution as a compound distribution of Binomial and Poisson distributions.

**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.

**Semester-IV**
**CORE Paper: Applied Statistics-1**
**Course Code: ST4502**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To discuss idea of statistical quality control and its applications. To explain methods of colleting vital statistics and concept of life table.

**Learning Outcomes:**
By the end of this course students are expected to understand preparation of control charts and construction of life table.

**Unit-1: Statistical Quality Control-1**
1. Introduction and importance of SQC.
2. Chance and assignable causes of variation in quality.
3. Determination of tolerance limits.
4. Theory of runs and criteria for detecting lack of control in the process.
5. Rational subgroups, natural tolerance of process and specification limits.

**Unit-2: Statistical Quality Control-2**
1. Control charts for Variables.
2. Construction of $\bar{X}$ , R and S charts with their interpretations.
3. OC function of $\bar{X}$ chart only.
4. Control charts for attributes.
5. Construction of p, np, c, u charts and their interpretations.

**Unit-3: Demographic methods (Vital Statistics)**
1. Sources of vital statistics in India, functions of vital Statistics, rates and ratios.
2. Mortality rates- Crude, Age Specific and Standard Death rates.
3. Fertility and reproduction rates, Crude birth rates general and specific fertility rates, gross and net reproductive rates.

**Unit-4: Life Table**
1. Introduction, notations and terminology.
2. Assumptions, description and construction of life table.

3. Theorems (without proof) on relationship between the various quantities defined in life table.
4. Stationary and stable population.
5. Central mortality rate.
6. Force of mortality.

**References**


1. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand Publication.
2. Pathak, K.B. and Ram, F.: Techniques of demographic analysis- Himalaya Publishing house (1992).
3. Srivastva, O.S.: A text book of demography (1982).
4. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics Vol. II, World Press, Calcutta.
5. MukhoPadhyay, P.:Applied Statistics, New Central Book Agency ( 1999)
6. Montgomery, D.C. (2001): Introduction to Statistical Quality Control, Wiley.
7. Grant, E.L. (2000): Statistical Quality Control, 7th Ed., Tata Mc Graw Hill Ott, E.R. (1975): Process Quality Control, McGraw Hill.
8. Wetherill, G.B. (1977): Sampling Inspection and Quality Control, Halsted Press.
9. Wetherill, G.B. and Brown, D.W.: Statistical Process Control, Theory and Practice, Chapman and Hall.


**Statistics Practical**
**Course Code: ST 4503L**
**No. of Credits: 03**
**Learning Hours: 60 hrs**

**Part A: Manual Calculation**

**Practicals are to be based on following topics**

Pr. 1 Control charts for variables.
Pr. 2 Control charts for attributes.
Pr. 3 Measurements of Mortality, Fertility and Population Growth.
Pr. 4 Life table.
Pr. 5 Generation of random sample from Weibull and Cauchy distribution.(using random number table)
Pr. 6 Fitting of Negative Binomial Distribution.
Pr. 7 Fitting of Geometric Distribution.
Pr. 8 Generation of random sample from Negative Binomial and Geometric distribution.(using random number table )

**Part B: Using Microsoft Excel**

**Practicals are to be based on following topics**

Pr. 1 Control charts for variables.
Pr. 2 Control charts for attributes.
Pr. 3 Measurements of Mortality, Fertility and Population Growth.

Pr. 4 Life table.
Pr. 5 Generation of random sample from Weibull and Cauchy distribution.
Pr. 6 Fitting of Negative Binomial Distribution.
Pr. 7 Fitting of Geometric Distribution.
Pr. 8 Generation of random sample from Negative Binomial and Geometric distribution.

**B.Sc. Semester – IV**
**Elective Course**
**Course Code: EG 4301 Economic Statistics-I**
**No. of Credits: 02**
**Learning Hours: 30 hrs**

**Unit-1: Time Series-1**
1. Meaning of Time series
2. various components of time series: Trend, Seasonal, Cyclic and Random components.

**Unit-2: Time Series-2**
1. Methods of measuring Trend by
   a. Graphical method
   b. Moving average methods
   c. Least squares method.

2. Measurement of Seasonal indices by
   a. Ratio to trend
   b. Ratio to moving average method.

**Unit-3: Index Number-1**
1. Introduction
2. Basic problems in the construction of index number
3. Limitations and uses of Index numbers.

**Unit-4: Index Number-2**
1. Construction of index number using in un-weighted and weighted aggregate methods
2. Tests of index number.

**References:**

1. Gupta, S.C., and Kapoor, V.K.: Fundamentals of Applied Statistics, Sultan Chand Publications**.**
2. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics Vol. II, World Press, Calcutta.
3. MukhoPadhyay, P.: Applied Statistics, New Central Book Agency (1999).


**Reference Website:**
1. www.sxca.edu.in
2. www.statsci.org/datasets.html (Data sets)

3. www.math.uah.edu/stat (Virtual laboratories in Statistics)
4. www.stat.ucla.edu/cases (Case studies in Statistics)
5. www.bmj.bmjournals.com (Excel data and Statistical Analysis)
6. www.psychstat.missouristate.edu (Introductory Statistics & Multivariate Statistics: Concepts, Models and Applications)
7. www.statpages.org (Web Pages that perform Statistical calculations)
8. www.amstat.org/publications/jse/jse-data-archive.html (Research Journals, magazines)
9. www.amstat.org/publications/chance (Chance magazine)
10. www.amstat.org/publications/stats (STATS: the magazine for students of Statistics)
11. www.freestatistics.org (for online software and search)

**Semester V**
**CORE Paper: Mathematical Statistics-III**
**Course Code: ST5501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To introduce two important continuous distributions namely the chi-square distribution and bivariate normal distribution. Along with these distributions the weak law of large number and Chebychev's inequality are derived / discussed.

**Learning Outcomes:**
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 alsobe able to apply weak law of large number and Chebychev's inequality to solve theoretical and practical problems arising in different branches of statistics.

**Unit-1: Chi-square Distribution**
1. Definition and derivation of Chi-square distribution
2. Mean and variance of Chi-square distribution
3. Mode and skewness of Chi-square distribution
4. Moment generating function and moments of Chi-square distribution
5. Cumulant generating function, cumulants and central moments of Chi-square distribution
6. Central MGF, Central moments and Pearson's coefficients of Chi-square distribution
7. Additive property of Chi-square distribution
8. Recurrence relation for central moments of Chi-square distribution
9. Definition of sum and ratio of two independent chi-square variates
10. The distributions of $\sum X_i^2$ , $\sum X_i^2/n$ , $\sqrt{\sum X_i^2}$ , , $\sqrt{\sum X_i^2/n}$ for $X_i \sim iid\ N(0, \sigma^2)$

11. Fisher's approximation of Chi-square distribution
12. Applications of Chi-square distribution
13. Examples of Chi-square distribution

**Unit-2: Probability Inequalities**

1. Chebychev's inequality( for continuous random variable)
2. Generalised form of Bienayme-Chebychev's inequality
3. Examples of Chebychev's inequality
4. Examples of generalised form of Chebychev's inequality
5. Examples to find upper and lower bounds of probabilities of some events based on different Distributions
6. Cauchy-Schawartz inequality
7. Boole's inequality
8. Jensen's inequality

**Unit-3: Weak Law of Large Numbers and Central Limit Theorem**

1. Convergence in Probability
2. Weak law of large numbers
3. Condition for applying Weak law of large numbers
4. Bernoulli's law of large numbers
5. Examples of Weak law of large numbers
6. Central limit theorems for equal and unequal components
7. Linderberg-Levy form of central limit theorem
8. Liapounoff form of central limit theorem (only statement)
9. Different particular cases of central limit theorem
10. Applications of central limit theorem

**Unit-4: Bivariate Normal Distribution**

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

**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 & Design of Experiment - I**
**Course Code: STA 5502**
**No. of Credits: 04**
**Learning Hours: 60 hours**

**Objectives:**
To discuss the concepts of statistical inference, characteristics of good estimator and various methods of estimation. To introduce the concept of ANOVA and designs of experiments.

**Learning Outcomes:**
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 learn to apply the technique of one way and two way ANOVA along with use of CRD.

**Unit-1: Estimator and its properties**
1. Notion of parameter, parameter space,
2. General problem of estimating an unknown parameter by point estimation
3. Concepts of statistic and estimator
4. Property of unbiasedness
5. Property of consistency
6. Sufficient condition for consistency
7. Property of efficiency
8. Property of sufficiency
9. Fisher- Neyman factorization theorem for sufficiency (for discrete random variable)

**Unit-2: Method of Estimation**
1. Minimum Variance Unbiased estimator (MVUE) - definition and properties
2. Cramer-Rao Inequality
3. Method of maximum likelihood estimator
4. Properties of maximum likelihood estimator
5. Method of moments
6. Method of confidence interval estimation

**Unit-3: Analysis of Variance**

1. Introduction of analysis of variance
2. Assumptions of ANOVA
3. One-way classification
4. Analysis of one-way classification
5. Critical difference
6. Two-way classification
7. Analysis of two-way classification

**Unit-4: Design of Experiment-I**

1. Basic idea and terminology of design of experiment
2. Principles of experimental design
3. Completely Randomized Design
4. Merits and demerits of CRD
5. Analysis of CRD
6. Post-hoc (HSD) test

**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. Mukhopadhyay, P. (1996): Applied Statistics, New Central Book Agency.
6. Rohtagi, V.K. (1967): An Introduction to Probability Theory and Mathematical Statistics,
7. John Wiley and Sons.
8. 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)
9. Goon, A.M., Gupta ,M. K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. I, WorldPress, Calcutta.
10. Stuart G & Ord J.K. (1991): Advanced Theory of Statistics (Vol 2), Charles Griffin
11. J. N. Kapoor, H. C. Saxena ( 1960): Mathematical Statistics, S. Chand & co.
12. Goon, A.M., Gupta, M.K. and Das Gupta, B. (1991): Fundamentals of Statistics, Vol. II, WorldPress, Calcutta.
13. M.N. Das & N. Giri : Design of experiments, ( Wiley Eastern Ltd )
14. Kempthorne :Design of Experiments,
15. Montgomery D.C. (1976): Design and Analysis of Experiments, John Wiley


**CORE Paper: Applied Statistics - II**
**Course Code: STA5503**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**

To discuss the procedures of various sampling methods, create estimates of population parameters and their standard errors. To expose the applicability of various acceptance sampling plans for attributes and variables.

**Learning Outcomes:**

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 theconfidence intervals for these estimates.

**Unit-1: Stratified Random Sampling**

1. Introduction
2. Estimation of population mean and total, standard error of estimators and estimation of standard errors
3. Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
4. Relative precision of stratified random sampling and simple random sampling
5. Determination of sample sizes when
6. Stratified random sampling for proportions

**Unit-2: Systematic Sampling**

1. Introduction
2. Estimation of population mean and standard error of the estimator
3. Advantages and limitations
4. Comparison of systematic sampling (N=nk) with SRSWOR and stratified sampling

**Unit-3: Two-Stage Sampling**

1. Introduction
2. Finding means and variances in two-stage sampling
3. Variance of the estimated mean in two-stage sampling
4. Sample estimation of the variance
5. The estimation of proportions
6. Optimum sampling and sub-sampling fractions

**Unit-4: Acceptance Sampling**

1. **Acceptance sampling plans for attributes**
   a. Concepts of AQL, LTPD, Producer's risk and Consumer's risk, OC curve, AOQ, AOQL, ASN, ATI for SSP only
   b. Construction of single sampling plan by fixing two points on the OC curve.

2. **Acceptance sampling plans for variables**
   A) When LCL is specified

a. σ is known
b. σ is unknown

B) When UCL is specified
a. σ is known
b. σ is unknown

C) Advantages and disadvantages of sampling plans for variables compared to sampling inspection plans for attributes

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


**CORE Paper: Quantitative Techniques-1(Operations Research)**
**Course Code: ST5504**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**

To discuss the concepts of decision theory, replacement theory, sequencing, PERT-CPM and inventory modelling. To expose the applicability of these quantitative techniques in different disciplines.

**Learning Outcomes:**

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.

**Unit-1: Decision Theory**

1. Introduction
2. Steps of decision making process
3. Types of decision making environment
4. Decision-Making under Certainty
5. Decision-Making under Risk
6. Decision-Making under Uncertainty

A) Decision making under Uncertainty Using following criteria
   a. Optimism (Maximax or Minimin) Criterion
   b. Pessimism (Maximin or Minimax) Criterion
   c. Equal Probabilities (Laplace) Criterion
   d. Coefficient of Optimization (Hurwitz) Criterion
   e. Regret (salvage) Criterion

B) Decision-Making under Risk
   a. Expected Monetary Value (EMV)
   b. Expected Opportunity Loss (EOL)
   c. Expected Profit of Perfect Information (EPPI)
   d. Expected Value of Perfect Information (EVPI)

**Unit-2: Replacement Theory and Sequencing Problems**

1. Introduction to Replacement theory
2. Types of Failure
3. Replacement policy form items whose Running Cost increases with Time and Value of Money Remains Constant during a Period
   a. When time t is a continuous variable
   b. When time t is a discrete variable
4. Replacement of items that fail completely (without proof)
   a. Individual Replacement Policy
   b. Group Replacement Policy
5. Introduction to Sequencing problems
6. Notations, Terminology and Assumptions
7. Processing n jobs through two machines
8. Processing n jobs through three machines
9. Processing n jobs through m machines.

**Unit-3: PERT-CPM**

1. Introduction
2. Basic difference between PERT and CPM
3. Significance of using PERT and CPM
4. Network Components and Precedence Relationships
5. Critical Path Analysis

a. Forward Pass Method
b. Backward Pass Method
c. Float of an activity
d. Critical Path

6. Project Scheduling with uncertain activity times

**Unit-4: Inventory Models**

1. Introduction
2. Meaning of Inventory Control
3. Function Role of Inventory
4. Reasons for carrying Inventory
5. Factors involved in Inventory Problem Analysis
   a. Relevant Inventory cost
   b. Demand for Inventory items
   c. Replenishment lead time
   d. Length of planning period
   e. Constraint on the Inventory system
6. Inventory Model building
7. Single item Inventory control models without shortages
   a. EOQ Model with Constant Rates of Demand
   b. EOQ Model with Different Rates of Demand
   c. EPQ Model When Supply (Replenishment) is Gradual
8. Single item Inventory control models with shortages
   a. EOQ Model with Constant Demand and Variable Order Cycle Time
   b. EOQ Model with Different Demand and Fixed Reorder Cycle Time
   c. EOQ Model with Gradual Supply and Shortage Allowed

**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 NonparametricStatistics,

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.

**Semester – V**
**Elective Course for B.Sc.**
**Statistics Using R**
**Credit: 2**
**No.of learning hours: 30hrs**

**Unit-1: Fundamentals of R**

1. 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
2. Creation of vectors using functions c, assign, seq, rep
3. Arithmetic operations on vectors using operators +, -, *, /, ^.
4. Numerical functions: log10,log,sort,max,min, unique, range, length, var, prod, sum, summary ect
5. Accessing vectors
6. Alternative ways to create vectors by scan function
7. Data frames :creation using data.frame, subset and transform commands
8. Resident data sets : Accession and summary
9. Graphics using R :
   a. High level plotting functions
   b. Low level plotting functions
   c. Interactive graphic functions

**Unit-2: Diagrams and Sampling Methods(Using R)**

1. Simple bar diagram, Subdivided bar diagram, multiple bar diagram, Pie diagram, Stem and leaf diagram
2. Box plot, rod or spike plot, histogram (both equal and unequal class intervals), frequency polygon, Ogive curves
3. Drawing a sample from population using SRSWR, SRSWOR
4. Stratified random sampling, systematic sampling

**Unit-3: Measures of Central Tendency, Dispersion, Skewness and Kurtosis (Using R)**

1. Mean, Mode, Median, Quartiles, Deciles, Percentiles, G.M and H.M.
2. Dispersion : variance, standard deviation, coefficient of variation, mean deviation
3. Skewness : Bowley's coefficient and Karl Pearson's coefficient of skewness
4. Moments : Computations of raw and central moments, measure of skewness and kurtosis based on it.

**Unit-4: Probability Distributions and Correlation and Regression (Using R)**

1. Simulation of random experiment Hyper geometric distribution : computation of probabilities
2. Binomial distribution : computation of probabilities, model sampling, fitting
3. Poisson distribution : computation of probabilities, model sampling, fitting
4. Normal distribution : computation of probabilities, model sampling,
5. Fitting of lines of regression, computation of correlation coefficient, Fitting of parabola
6. Multiple Regression: Fitting of regression plane for trivariate data.

**References:**

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

**Statistics Practical**
**STA: 5505 L**
**Credit: 3**
**(Duration: 12 Hours per week)**

**Practical Paper-1**

1. Drawing a random sample from Bivariate Normal distribution
2. Drawing a random sample from Bivariate Normal distribution
3. Chi-square test to test the goodness of fit
4. Chi-square test to test the independence of attributes for 2x2 contingency table
5. Chi-square test to test the significance of difference of observed and expected frequencies.
6. Chi-square test to test the independence of attributes for mxn contingency table
7. Chi-square test to test the homogeneity of correlation coefficient.
8. One-way classification
9. Two-way classification
10. Completely Randomized Design

**Practical Paper-2**

1. Stratified Random sampling : Estimation of population mean and total, standard error of estimators and estimation of standard errors
2. Stratified Random sampling : Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
3. Stratified Random sampling : Allocations of sample size- Proportional, Neyman and Optimum allocations for fixed cost and fixed precision
4. Stratified Random sampling :Relative precision of stratified random sampling and simple random sampling
5. Systematic sampling: Estimation of population mean and standard error of the estimator
6. Systematic sampling: Estimation of population mean and standard error of the estimator
7. Two-stage sampling :Estimation of population mean and standard error of the estimator
8. Two-stage sampling : Estimation of population mean and standard error of the estimator
9. Single sampling plan: AQL, LTPD, Producer's risk and Consumer's risk

10. Single sampling plan : OC curve, AOQ, AOQL, ASN, ATI for SSP only
11. Single sampling plan : OC curve, AOQ, AOQL, ASN, ATI for SSP only

**Practical Paper-3**

1. Drawing of PERT diagram
2. Estimation of Project completion time
3. Estimation of Project completion time
4. Critical Path method
5. Replacement problem (Processing n jobs through two machines, through three machines)
6. Replacement problem (Group Replacement)
7. Decision theory (under certainty)
8. Decision theory: Optimism and Pessimism Criterion, Equal Probabilities (Laplace) Criterion, Coefficient of Optimization (Hurwitz) Criterion, Regret (salvage) Criterion
9. Decision theory :Expected Monetary Value (EMV), Expected Opportunity Loss (EOL), Expected Profit of Perfect Information (EPPI), Expected Value of Perfect Information (EVPI)
10. Inventory theory : Single item Inventory control models without shortages
11. Inventory theory : Single item Inventory control models with shortages

**Practical Paper-4 (Using SPSS and Microsoft Excel)**

1. Drawing a random sample from Bivariate Normal distribution
2. Drawing a random sample from Bivariate Normal distribution
3. Application of Chi-square distribution to test the goodness of fit
4. Application of Chi-square distribution to test the independence of attributes
5. One-way classification (Equal size of classes)
6. One-way classification (Unequal size of classes)
7. Two-way classification
8. Completely Randomized Design
9. Decision theory

**Semester VI**
**CORE Paper: Mathematical Statistics-IV**
**Course Code: ST6501**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**

To discuss concepts truncated distributions, characteristic function, order statistics, Student's t, Fisher's F and Z distribution

**Learning Outcomes:**

By the end of this course students are expected to be able to obtain probability distribution of truncated distributions, Student's t, Fisher's F and Z distribution along with their properties. They will also learn to derive and use the characteristic function of different distributions.

**Unit-1: Truncated Distributions**

1. Definition of truncated distributions from left, right and both sides
2. Binomial Distribution truncated at X=0 and its mean, variance and MGF
3. Poisson Distribution truncated at X=0 and its mean, variance and MGF
4. Standard Normal Distribution truncated from both sides and its mean, mode and variance
5. Normal Distribution truncated from both sides and its mean, variance and MGF
6. Standard Cauchy Distribution truncated at both ends with relevant range of variation as $(-\beta, \beta)$ and its mean and variance
7. One variate Gamma distribution truncated at X=A from left and its pdf and expression for $r^{th}$moment about origin
8. 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.
9. 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.

**Unit-2: Characteristic Function**

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

**Unit-3: Student's t-Distribution and Fisher's F-distribution**

1. Definition and Derivation of Fisher's t-distribution
2. Derivation of student's t distribution
3. Even and Odd ordered moments of t-distribution
4. Approximation of t-distribution to Normal distribution
5. Distribution of sample correlation-coefficient r
6. Properties and examples of t-distribution
7. Definition and Derivation of Snedecor's F-distribution
8. Mean, mode and variance of F–distribution

9. Relation between t and F distribution
10. Relation between F and $\chi^2$–distribution
11. Applications and examples of F-distribution

**Unit-4: Fisher's Z Distribution and Order Statistics**

1. Definition and Moment generation function of Z-distribution
2. Fisher's Z-transformation
3. Applications and Examples of Z-distribution
4. Definition of Order Statistics
5. Cumulative distribution function of a single Order statistic
6. Probability density function of a single Order statistic
7. Joint Probability density function of two Order statistics
8. Joint Probability density function of k-Order statistics
9. Joint Probability density function of all n-Order statistics
10. Distribution of Range of Order statistics
11. Examples of Order statistics

**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 &Design of Experiment-II**
**Course Code: STA 6502**
**No. of Credits: 04**
**Learning Hours: 60 hours**

**Objectives:**

To introduce idea of statistical hypothesis and their testing along with designs of experiments using RBD, LSD and factorial experiments

**Learning Outcomes:**

By the end of this course students are expected to be able to test the statistical hypothesis using NP Lemma and Likelihood ratio test. They will also be able to analyse the problem of with the help of technique of various designs of experiments.

**Unit-1: Testing of Hypothesis -I**

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

**Unit-2: Testing of Hypothesis -II**

1. Uniformly most powerful test (for one –sided alternative hypothesis)
2. Likelihood Ratio Test
3. Properties of likelihood ratio test
4. Applications of Likelihood Ratio Test

**Unit-3: Design of experiment-II**

1. Layout of Randomized Block Design
2. Merits and demerits of RBD
3. Statistical analysis of RBD
4. Estimation of missing observation/s and its analysis
5. Layout of Latin square design
6. Merits and demerits of LSD
7. Statistical analysis of LSD
8. Estimation of missing observation/s and its analysis
9. Efficiencies of design.

**Unit-4: Factorial Experiment**

1. Concept and need of factorial experiments
2. Idea of terms – main and interaction effect, confounding – total and partial,
3. Yates' Procedure and Yates' table
4. $2^2$ and $2^3$ factorial experiment
5. Main effects and interactions, their best estimates and testing the significance when underlying design is RBD
6. Concept of confounding – Total and Partial Confounding
7. Confounding in $2^3$ factorial experiment

**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
8. Hogg, R.V. and Craig, A.T. (1972): Introduction to Mathematical Statistics, Amerind Publishing Co.
9. K.R. Koch (1987) : Parameter Estimation and Hypothesis Testing in Linear Models,
10. Mood, A.M., Greybill, F.A. and Bose, D.C. (1974): Introduction to the Theory of Statistics, McGraw Hill.
11. Mukhopadhyay, P. (1996): Mathematical Statistics, New Central Book Agency.
12. S.C. Gupta &V.K. Kapoor( 2010): Fundamentals of Mathematical Statistics, S. Chand & co.

**CORE Paper: Analytical Methods for Statistics**
**Course Code: ST6503**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**
To discuss concept of Jacobian of transformation, multiple integration, riemannstielties integration, sequence and series.

**Learning Outcomes:**
By the end of this course students are expected to be able to solve the problem of mathematical analysis based on the applications of Jacobian of transformation, multiple integration, riemannstielties integration, sequence and series.

**Unit-1: Jacobian of Transformations**
1. Jacobian of transformation
2. Coordinate and polar transformations
3. Implicit function theorem (Statement Only)
4. Existence for inverse transformation
5. Functional dependence
6. Leibnitz's theorem for inverse transformations
7. Functional dependence
8. Leibnitz's theorem with proof relatingto differentiation under integral signs and its Applications
9. Applications of Jacobian of transformations

**Unit-2: Multiple Integration**
1. Jacobian of transformation in multiple intregrals
2. Dirichlet's integral in n-dimension
3. Use of Dirichlet's integral in obtaining the volume and surface area of an n-dimensional sphere of radius r
4. Sampling distribution of some statistics

5. Examples based on multiple integration

**Unit-3: Riemann Stieltjes Integrals**

1. Definition
2. Existence of Rieman- Stieltjes integral
3. Integration & Differentiation
4. Fundamental theorem of calculus and integration by parts

**Unit-4: Sequence and Series**

1. Convergence of a sequence, subsequences, Cauchy sequences
2. Limit superior and limit inferior of a sequence
3. Special sequences, series, root and ratio tests for convergences of a series
4. Absolute convergence

**References:**


1. Shanti Narayan (1984): a course of Mathematical Analysis, S. Chand & Company Ltd.
2. Walter Rudin : Principle of Mathematical analysis third edition, Mcgrow Hill
3. John M. H. : Advance Calculus, Eurasia Publishing House, Delhi.
4. V. K. Krishnan (2004) : Fundamentals of Real Analysis, PEARSON Education.


**CORE Paper: Quantitative Techniques - 2 (Operation Research)**
**Course Code: ST6504**
**No. of Credits: 04**
**Learning Hours: 60 hrs**

**Objectives:**

To introduce quantitative techniques of linear programming problem, transportation problem, assignment problem, game theory. Along with the methods of solutions of these problems.

**Learning Outcomes:**

By the end of this course students are expected to be able to obtain optimumsolution of the problems arising in business, industry, social science by using the method of graphical, simplex, Vogel's method, MODI method, Hungarian method. They will also be able to solve simple problems using the concept of game theory.

**Unit-1: Operation Research and Linear Programming: The Graphical Method**

1. Introduction of Operation Research
2. Modelling in Operation Research
3. General Methods for solving Operation Research Models
4. Advantages of Operation Research study
5. Introduction and Structure of LPP Model
6. Advantages and Limitations of using Linear Programming
7. General Mathematical Model of LPP

8. Examples of LP Model formulation
9. Introduction and Important definitions of Graphical Method
10. LPP Solution using Graphical Method

**Unit-2: Linear Programming: The Simplex Method**

1. Introduction
2. Standard form of an LP problem
3. Simplex Algorithm (Maximization case)
4. Simplex Algorithm (Minimization case)
5. Big – M method
6. Two Phase method
7. Duality in Linear Programming(without proof of theorem)
8. Formulation of dual LPP

**Unit-3: Transportation Problem (TP) and Assignment Problem (AP)**

1. Introduction
2. General Mathematical Model of TP
3. The Transportation Algorithm(without proof)
4. Methods of finding Initial solution
   a. North West Corner Rule
   b. Least Cost Method
   c. Vogel's Approximation Method
5. MODI method of finding Optimum solution
6. Variations in TP
   a. Unbalanced Supply and Demand
   b. Degeneracy and its Resolution
   c. Prohibited Transportation Routes
   d. Maximization case in Transportation Problem
7. Mathematical Model of Assignment Problem
8. Optimum Solution of AP by Hungarian method
9. Variations in AP
   a. Multiple Optimal Solutions
   b. Maximization case
   c. Unbalanced AP
   d. Prohibited AP

**Unit-4: Game Theory**

1. Introduction
2. Two-Person Zero Sum Game
3. Pure Strategies: Game with Saddle Point
4. Mixed Strategies: Game without Saddle Point
5. Dominance Property
6. Solution for Games without Saddle Point by Algebraic Method

**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 Course Semester – VI**

**Course Code: 6301**

**Complex Numbers**

**Credit: 2**

**Unit-1: Complex Numbers-I**

1. Definition, equality of two complex numbers
2. Fundamental operations of complex numbers
3. Basic Algebraic properties of complex numbers
4. Further properties of complex numbers
5. Inverse of complex numbers and division by non-zero complex numbers
6. Geometric reorientation of complex numbers sum of two complex numbers and difference of two complex numbers
7. Complex conjugates
8. Exponential from
9. Products and quotients in exponential from

**Unit-2: Complex Numbers-II**

1. Modulus and Conjugates of complex numbers
2. Properties of Modulus
3. Polar co-ordinates and Properties of arguments
4. Multiplications by i

5. Powers and roots of complex numbers
6. Regions in the complex plan bounded points , closed set , open set, connected set ,interior

**Unit-3: Analytic Functions**

1. Function of a Complex variables
2. Limits of function and examples
3. Theorems on limits and examples
4. Continuity of a function and Examples of continuity
5. Theorems of continuity function(without proof)
6. Derivatives of complex numbers and its theorems
7. Differentiation formulas without proof
8. Cauchy-Riemann equations –necessary condition with proof and sufficient condition without proof and its examples
9. Harmonic function, and necessary and sufficient condition for analytic with proof and its examples
10. Pole-residue of complex function

**Unit-4: Elementary Functions**

1. Exponential function
2. Properties and examples of Exponential function
3. Trigonometric functions and their derivatives
4. Properties of Trigonometric functions
5. Hyperbolic functions and its examples

**References:**


1. Complex variables and applications , $7^{th}$ edition James Ward Brown , Ruel V. Churchill , Mc Graw Hill
2. Complex analysis by J. M. Howie


**Statistics Practical**
**STA: 6505 L**
**Credit: 3**
**(Duration: 12 Hours per week)**

**Practical Paper-1**

1. Fitting of Truncated Binomial Distributions
2. Fitting of Truncated Poisson Distributions
3. Drawing a random sample fromTruncated Binomial Distributions
4. Drawing a random sample from Truncated Poisson Distributions
5. t-test of significance for single mean and confidence limits
6. t- test to test the significance difference between two population means and pair t-test for difference of means

7. t- test to test the significance of population correlation coefficient and
8. F-test for equality of population variances
9. F- test for to test of significance multiple and partial correlation coefficient
10. Z-test to test the significance of difference between observed value and hypothetical value of population correlation coefficients
11. Z-test to test the significance of difference between two independent population correlation coefficients

**Practical Paper-2**

1. Randomized Block Design
2. Estimation of missing observations(one/Two) in RBD
3. Latin Square Design
4. Estimation of missing observations (one/Two)in LSD
5. $2^2$ factorial experiment
6. $2^3$ factorial experiment
7. Total confounding in $2^3$ factorial design
8. Partial confounding in $2^3$ factorial design
9. Probabilities of Type – I and Type – II errors, Power curve
10. 10) Obtaining best critical region for MP test

**Practical Paper-3**

1. Formulation of linear programming problem
2. Graphical method for solving LPP
3. Simplex method for Solving LPP
4. Simplex method for Solving LPP
5. Big-M method for LPP
6. Initial Basic feasible solution to a Transportation problem
7. Finding optimum solution to a transportation problem
8. Hungarian method for solving assignment problem
9. Duality in LPP
10. Game theory

**Practical Paper-4 (Using R and Microsoft Excel)**

1. Fitting of Truncated Binomial Distributions
2. Fitting of Truncated Poisson Distributions
3. Drawing a random sample from Truncated Binomial Distributions
4. Drawing a random sample from Truncated Distributions
5. Randomized Block Design
6. Latin Square Design
7. Graphical method for solving LPP
8. Simplex method for Solving LPP
9. Big-M method for LPP