# Department of Statistics
# Central University of Rajasthan


## SYLLABUS
## for

## Integrated M. Sc. STATISTICS (Semester I to VI)

Proposed to be implemented for the existing 2015 batch and batches admitted in academic year 2016 onwards and for students admitted in academic year 2019 and onwards

Department of Statistics
School of Mathematics Statistics and Computational Sciences
Central University of Rajasthan
Bandarsindri, NH-8, Kishangarh, Ajmer, Rajasthan-305801

**Programme Objective:**

The main objective of Integrated M.Sc. in Statistics programme in CURaj is to facilitate higher secondary passed students to learn, practice and make career in the art of information analysis for the purpose of decision making on concerned problems. Analysis can be done by using well accepted principle and scientific methods developed in Statistics. As these students have chosen the statistics at an early stage of their learning, they have an opportunity of better understanding fundamentals of statistics and equip themselves to work as a professional statistician. Training in statistical computing will enhance their job opportunities and professional skills.

**Learning outcome of this program,**

After the completion of Integrated M.Sc. programme, students will:

1. Learn the art of representing and dealing with random phenomenon
2. Learn basic principles and statistical concepts used in decision making
3. Learn art of gathering information by sampling and designing experiments and analyzing it
4. Be able to assist researchers for drawing inferences using their experimental out comes
5. Be able to develop and validate models on the basis of collected data

# Revised Course Outline

Integrated M.Sc. Statistics

## I to VI Semester

| Sem. | Revised Code | Title | Credit | Hours | | |
|---|---|---|---|---|---|---|
| | | | | Lectures | Tutorial | Practical |
| I | STA 101 | Descriptive Statistics | 3 | 3 | 0 | 0 |
| | STA 102 | Practicals | 1 | 0 | 0 | 2 |
| II | STA 103 | Probability and Random Variables | 3 | 3 | 0 | 0 |
| | STA 104 | Practicals | 1 | 0 | 0 | 2 |
| III | STA 201 | Probability Distributions | 3 | 3 | 0 | 0 |
| | STA 202 | Practicals | 1 | 0 | 0 | 2 |
| IV | STA 203 | Statistical Inference-I | 3 | 3 | 0 | 0 |
| | STA 204 | Practicals | 1 | 0 | 0 | 2 |
| V | STA 301 | Sample Survey | 3 | 3 | 0 | 0 |
| | STA 302 | Applied Statistics | 3 | 0 | 0 | 0 |
| | STA 303 | Theory of Attributes and Design of Experiments | 3 | 0 | 0 | 0 |
| | STA 304 | Practicals | 3 | 0 | 0 | 6 |
| | | Open Elective (Science) | 3 | 3 | 0 | 0 |
| | | Open Elective (Social Science) | 3 | 3 | 0 | 0 |
| VI | STA 305 | Operation Research | 3 | 0 | 0 | 0 |
| | STA306 | Reliability and Survival Analysis | 3 | 3 | 0 | 0 |
| | STA 307 | Statistical Inference -II | 3 | 3 | 0 | 0 |
| | STA 308 | Practicals | 3 | 0 | 0 | 6 |
| | | Open Elective (Science) | 3 | 3 | 0 | 0 |
| | | Open Elective (Social Science) | 3 | 3 | 0 | 0 |

# FIRST SEMESTER

| Course Code | STA 101 |
|---|---|
| Course Name | Descriptive Statistics |
| Credit | 03 |

**Objective:**

To make the students aware of different type of data sets and their graphical representations introducing of descriptive statistical measures, including those for two variables

**Learning Outcome:**

- Graphical and Diagrammatic representation of data.
- Calculation of Moments, understanding of Measures of Central Tendency , Dispersion , Skewness and Kurtosis with their interpretations.
- Calculation, Interpretation and application of Correlation and Regression Analysis.

**COURSE OUTLINE**

**Unit-1**

Meaning and scope of the word *'Statistics'*. Data types: Qualitative and Quantitative Data scales of measurements: nominal, ordinal, ratio, interval Representation: Tabulation Compilation, Classification. Graphical and diagrammatic representation: Bar diagrams, multiple and stack bar diagrams, Histogram, Frequency Polygon, Frequency Curve, O-give, Pie diagram, Box plot, Stem and leaf diagrams.

Measures of Central Tendency: Concept, requirements of a good measure. Arithmetic Mean, Geometric Mean, Harmonic Mean, Median, Mode: properties, merits and demerits. Quartiles, Deciles and Percentiles, Graphical method of determination of Median, Mode and Quantiles.

**Unit-2**

Measures of Dispersion: Concept, Requirements of a good measure of dispersion. Range: Quartile Deviation (Semi-interquartile range): Coefficient of Q.D. Mean Deviation (M. D.), Proof of Minimal property of M.D. Mean Square Deviation: proof of Minimal property of M.S.D.Variance and Standard Deviation(S.D): Effect of change of origin and scale, S.D. of pooled data (proof for two groups), Coefficient of Variation.

Moments: Raw moments and Central moments, relation between central moments and raw moments, Sheppard correction for moments (without derivation),Skewness: Measure of skewness, Types of skewness, Kurtosis, Types of kurtosis, Measure of kurtosis.

**Unit-3**

Bivariate Data. Scatter diagram. The concept of dependency, illustrative real life examples. Covariance: Definition, Effect of change of origin and scale. Karl Pearson's coefficient of correlation (r): Definition, Properties, Spearman's rank correlation coefficient: Definition, Interpretation. Derivation of the formula for without ties and Modification of the formula for with-ties computation, variance of linear combination of variables. Correlation coefficient for discrete frequency distribution.

Concept of regression, Lines of regression, Principal of least square and cure fitting. Fitting of lines of regression by the least square method. Regression coefficients ($b_{xy}$, $b_{yx}$) and their geometric interpretations, Properties. Derivation of the point of intersection of two regression lines and the acute angle between the two lines of regression.

**References**


1. Rohatgi V. K. and Saleh A. K. Md. E., An Introduction to probability and Statistics. John Wiley & Sons (Asia).
2. Mukhopadhyay, P., Mathematical Statistics, new Central Book Agency Pvt. Ltd., Calcutta.
3. Hoel P. G., Introduction to Mathematical Statistics, Asia Publishing House.
4. Meyer P. L., Introductory Probability and Statistical Applications, Addision Wesley.
5. AM Goon, M K Gupta and B. Das Gupta, Fundamentals of Statistics, Volume-I, World Press

| Course Code | STA 102 |
|---|---|
| Course Name | Practicals |
| Credit | 01 |

**Objective:**

To get better understanding and implement the concepts learnt in the theory by using data sets
To have hand-on experience/training to use MS Excel software.

**Learning Outcome:**

- Developing skills to represent and analysis data sets using MS Excel software.

Students will be required to do practical, based on topics listed below, using MS Excel:

1. Introduction to MS Excel: Data storage, elementary calculations and graphical representations.
2. Tabulation and Construction of frequency distribution
3. Diagrammatic (Multiple stack bar diagrams, histogram, stem and leaf, pie chart) and graphical
6. (frequency polygon, frequency curve) presentation of the frequency distribution.
4. Measures of Central tendency - I (ungrouped data).
5. Measures of Central tendency - II (grouped data).
6. Measures of Central tendency - III (pooled data).
7. Computation of quantiles by use of Ogive curves,
8. Measures of the Dispersion - I (ungrouped data).
9. Measures of the Dispersion - II (grouped data).
10. Moments, Skewness & Kurtosis-I (ungrouped data).
11. Moments, Skewness & Kurtosis-II (grouped data).
12. Computation of raw, central moments, Pearson's coefficient of skewness and kurtosis.
13. Scatter diagram for bivariate data and interoperation.
14. Product moment correlation and Spearman Rank correlation (tied with un tied rank)
15. Correlation coefficient for bivariate frequency data.
16. Curve fitting using method of least square.
17. Regression lines.

# SECOND SEMESTER

| Course Code | STA 103 |
|---|---|
| Course Name | Probability and Random Variables |
| Credit | 03 |

**Objective:**

To introduce the notion of probability, random variable and expectation, based on which statistical theory and tools have been developed.

**Learning Outcome:**

- Describing stochastic/random behaviour of variables, using the concept of probability
- Computation of probabilities of events.
- The notion of distribution.
- Computation of moments and other related functions of a distribution.

Concepts of experiments: deterministic, probabilistic, outcomes of experiments. Sample space, Discrete (finite and countably infinite) and continuous sample space, Event, Elementary event, Compound event. Algebra of events (Union, Intersection, Complementation), De Morgan's law. Definitions of Mutually exclusive events, Exhaustive events, Venn diagram. Definition; Axiomatic definition of probability; Addition theorem (Proof of the result up to three events), Elementary properties, Classical definition of Probability as a special case, Probability as an approximation to the relative frequency, illustrative examples for computation of events based on Permutations and Combinations, with and without replacements, impossible events, certain events.

Definition of conditional probability of an event, Multiplication theorem for two events, Independence of events: Pairwise and Mutual Independence of events. Partition of sample space. Statement and proof of Bayes' theorem.

**Unit-2**

Definition of random variable, Discrete and continuous and mixed type of random variables, Definition of distribution function, Distributions function (df) of random variable, Probability distribution of function of random variable. Probability mass function (p.m.f.) and cumulative distribution function (c.d.f.) of a discrete random variable, Probability density function (p.d.f.) and cumulative distribution function (c.d.f.) of a continuous random variable, relation between df and pmf/pdf, Median and Mode of a univariate discrete and continuous random variables.

**Unit-3**

Definition of expectation of a random variable, expectation of a function of a random variable, simple properties, Definitions of mean, variance of univariate distributions, Effect of change of origin and scale on mean and variance, Definition of raw, central moments, mean deviation. Pearson's coefficient of skewness, kurtosis, Definitions probability generating function (p.g.f.), moment generating function (m.g.f.) and characteristic function of a random variable, Effects of change of origin and scale. p.g.f. of sum of two independent random variables is the product of p.g.f.s (statement only), Derivation of mean and variance by using p.g.f.

**References**


1. Mood A. M. , Grabyll R. A. and Boes D. C., Introduction to the theory of Statistics, Tata McGraw Hill
2. Mukhopadhyay, P., Mathematical Statistics, new Central Book Agency Pvt. Ltd., Calcutta.
3. AM Goon, M K Gupta and B. Das Gupta, Fundamentals of Statistics, Volume-I, World Press.
4. Ross Sheldon M., Introduction to Probability Models, Academic Press
5. Rao, B. L. S. Prakash, A first course in probability and Statistics, World Scientific.

| Course Code | STA 104 |
|---|---|
| Course Name | Practicals |
| Credit | 01 |

**Objective:**

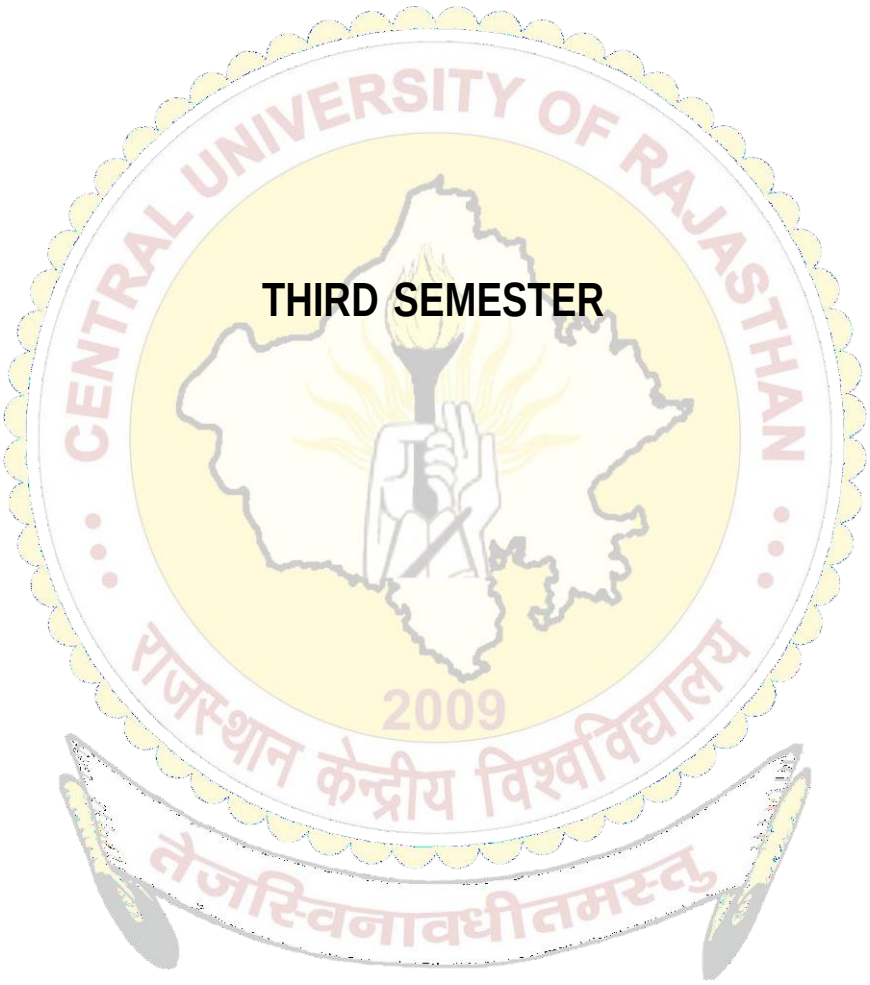
- to enhance the skills of computing probabilities, related functionals, plotting of density and density functions

**Learning Outcome:**

- Learn to compute probabilities, conditional probabilities
- Learn to plot functions using softwares.

**CONTENTS**

(i) Illustrations related to probability, Conditional probability, and Bayes Theorem.
(ii) Probability mass function plot of discrete r.v.
(iii) Probability density plot of continuous r.v.
(iv) Computation of expectation, variance, third and forth moment for pmf.
(v) Computation of coefficient of Skewness and Kurtosis.
(vi) Computation of probabilities through probability generating function.




# THIRD SEMESTER

| Course Code | STA 201 |
|---|---|
| Course Name | Probability Distributions |
| Credit | 03 |

**Objective:**
The main objective is to introduce standard discrete and continuous distributions.

**Learning Outcome: Students will know**

- Standard Discrete and Continuous Distributions.
- Method of obtaining distributions of transformed variables
- Inter relationships between typical random variables
- Application of various distributions.

**Unit-1**

Discrete Distribution: General concept of a finite discrete random variable De-generate, Discrete Uniform, Bernoulli, Binomial, Poisson and Geometric, Negative Binomial, Hyper geometric and Multinomial distributions with their properties and applications.

**Unit-2**

Continuous Distribution: Rectangular, Normal distribution, Exponential, Gamma, and Beta (I and II kind) with their properties and applications. Normal distribution as limiting case of binomial and Poisson distribution.

**Unit-3**

Concept of bivariate rv and their distribution function. Function of random variables in one dimensional and two dimensional using (i) Jacobian of transformation (ii) Distribution function and (iii) M.G.F. technique.

Exact sampling distributions: Chi square distribution, Student's t- distribution and Snedecor's F distribution. Definitions, derivation of p.d.fs, sketch of p.d.fs. for various values of parameter, moments. Inter relation between t, F and $\chi 2$ (without proof). Applications of t, F and $\chi 2$ distributions.

**References**


1. Rohatgi V. K. and Saleh A. K. Md. E., An Introduction to probability and Statistics. John Wiley & Sons (Asia).
2. Hogg R.V. and Criag A.T.: Introduction to Mathematical Statistics (Third edition), Macmillan Publishing, New York.
3. Walpole R.E. & Mayer R.H.: Probability & Statistics, MacMillan Publishing Co. Inc, New York
4. Mayer P.L.: Introductory probability & Statistical Applications. Addison Weseley Publication Co., London.
5. Goon A.M., Gupta A.K. and Dasgupta B.: Fundamentals of Statistics (Vol. II) World Press, Calcutta.
6. Mukhopadhyay P. (1996): Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta.

| Course Code | STA 202 |
|---|---|
| Course Name | Practicals |
| Credit | 01 |

**Objective:**

- To enhance the computing, sketching simulating skills

**Learning Outcome:**

- Computing and sketching of distribution functions
- Learn fitting of models for data sets
- Learn the art of simulation from models.

**CONTENT**

Students will be required to do practicals, based on topics listed below, using R / MS Excel:

(i) PMF sketch of Discrete Distributions: Uniform, Binomial, Poisson, Geometric, Negative Binomial, Hyper-geometric.
(ii) Computation of Expectation, Variance, Mode, and Skewness and Kurtosis for above discrete distributions.
(iii) PDF sketch of Continuous Distributions: Rectangular, Exponential, Normal, Gamma and Beta-I and II.
(iv) Computation of Expectation, Variance, Mode, and Skewness and Kurtosis for above continuous distributions.
(v) Computation of probabilities based on area property of normal distribution.
(vi) Fitting of distributions: Binomial, Poisson, Normal distributions.
(vii) Simulation of data from discrete and continuous distributions

# FORTH SEMSTER

| Course Code | STA 203 |
|---|---|
| Course Name | Statistical Inference-I |
| Credit | 03 |

**Objective:**
The main objective is to build the theoretical foundation of Point Estimation and Testing of Hypothesis and to introduce the notion of order statistics

**Learning Outcome: Students will**

- Be able to obtain distributions of order statistics.
- Learn basic concept in inference different estimation techniques used in statistics.
- Learn methods of estimation and testing of hypothesis properties of a good estimator.

**Unit-1**

Order statistics: Definition, derivation of p.d.f. of $i^{th}$ order statistics, for a random sample of size n from a continuous distribution. Density of smallest and largest observations. Derivation of joint p. d. f. of $i^{th}$ and $j^{th}$ order statistics, statement of distribution of the sample range. Distribution of the sample median.

**Unit-2**

Concept of Statistical inference, sampling method and complete enumeration, Definition of population, parameter, parameter space. Problem of estimation: point, intervals and testing of hypotheses.
Definitions of an estimator, mean squared error (MSE) of an estimator, comparison of estimators based on MSE function. Unbiasedness: Unbiased estimator, Illustration of unbiased estimator for the parameter and parametric function. Definitions of Consistency, Sufficient condition for consistency, concept of efficiency and sufficiency. Neyman-Factorization theorem (without proof)

**Unit-3**

Methods of estimation: Methods of moments, concept of likelihood function, Maximum Likelihood, Properties of MLE (without proof), Estimation of the parameters of normal distribution and other standard distributions by MLE.

Hypothesis, types of hypothesis, problems of testing of hypothesis, critical region, type I and type II errors, probabilities of type I & type II errors. Power of a test, best critical region, Observed level of significance, concept of p-value, size of a test, level of significance.

Definition of Most Powerful (MP) test, Neyman - Pearson (NP) lemma for simple null hypothesis against simple alternative hypothesis (with proof)- Illustrations. Power curve of a test.

**References**


1. George Casella, Roger L. Berger (2002), Statistical Inference, 2nd ed., Thomson Learning.
2. Mukhopadhyay P. (1996): Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta.
3. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
4. Goon, Gupta & Das Gupta (1991): An Outline of Statistical Theory, Vol. II, World Press.
5. Hogg, R.V. and Craig, A.T. (1971): Introduction to Mathematical Statistics, McMillan.

| Course Code | STA 204 |
|---|---|
| Course Name | Practicals |
| Credit | 01 |

**Objective:**

The main objective is to enhance the practical knowledge of concepts learnt in the theory course of this semester by using Computer Software.

**Learning Outcome:**

- Learn to obtain and sketch densities of order statistics
- Students will be able to implement methods estimation and testing by using appropriate methods and computing softwares.

**CONTENT**

Students will be required to do practicals, based on topics listed below, using R / MS Excel:

(i) Density plot of maximum and minimum of sample for different discrete and continuous distributions.
(ii) Density of *i*-th order statistics.
(iii) Point estimation by Method of moments.
(iv) Maximum likelihood estimation.
(v) Mean squared error and unbiasedness of an estimator
(vi) Type I and Type II errors
(vii) Most powerful critical region (NP Lemma)
(viii) Power curves.

# FIFTH SEMESTER

| PAPER CODE | STA 301 |
|---|---|
| PAPER NAME | Sample Survey |
| CREDIT | 03 |
| TOTAL HOURS | 45 |

**Objective:**

The main objective is to provide the knowledge of concept of sample and population in statistics and also the various sampling schemes and estimation of population parameters and their respective standard errors.

**Learning Outcome:**

- Learning the basic concept of sampling and related terminologies.
- Understanding various types of sampling schemes, with their advantages and disadvantages, and estimation of population parameters with their standard errors.
- Learning the use of auxiliary information in the ratio and regression method of estimation.

**Unit-1**

Basic concept: Elementary units, sampling frame, random and non-random sampling. Sampling, census advantages of sampling, Questionnaire and its characteristics.

Simple random sampling: Simple random sampling from finite population of size N with replacement (SRSWR) and without replacement (SRSWOR): Definitions, population mean and population total as parameters, inclusion probabilities. Sample mean as an estimator of population mean, derivation of its expectation. Estimation of population proportion: Sample proportion (p) as an estimator of population proportion (P), derivation of its expectation, using SRSWOR. Determination of the sample size. Concept of Stratification, methods of allocation, Cost and variance analysis in stratified random sampling

**Unit-2**

Systematic Sampling: Real life situations where systematic sampling is appropriate, Technique of drawing a sample using systematic sampling, Estimation of population mean and population total, Comparison of systematic sampling with SRSWOR and stratified sampling in the presence of linear trend. Idea of Circular Systematic Sampling.

Cluster Sampling: Real life situations where cluster sampling is appropriate, Technique of drawing a sample using cluster sampling, Estimation of population mean and population total (with equal size clusters)

**Unit-3**

Ratio Method: Concept of auxiliary variable and its use in estimation, Situations where Ratio method is appropriate, Ratio estimators of the population mean and population total and their standard errors (without derivations), Relative efficiency of ratio estimators with that of SRSWOR. Regression Method: Situations where Regression method is appropriate, Regression estimators of the population mean and population total and their standard errors.

**References**


1. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
2. Sukhatme, P.V., Sukhatme, B.V. and Ashok A. : Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
3. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
4. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs,Wiley Eastern Ltd., New Delhi.
5. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

| Course Code | STA 302 |
|---|---|
| Course Name | Applied Statistics |
| Credit | 03 |

**Objective:**

The main objective is to make aware of statistics in Demographic Studies, Index Numbers, Time Series Data, and Statistical Quality Control.

**Learning Outcome:**

- Learning the importance of statistical techniques and concepts in the different areas of applied statistics.
- To make aware of the use of statistical techniques in decision making.

**Unit-1**

Vital Statistics: Census, Registrar, Ad-hoc surveys, Hospital records, Demographic profiles of the Indian census. Crude death rate, Age-specific death rate, Infant mortality rate, Death rate by cause, standardized death rate. NRR and GRR . Life Table: Description and construction of complete and abridged life tables and their uses.

**Unit-2**

Index Number: Meaning and utility of index numbers, problems in construction of index numbers. Types of index numbers: price, quantity and value, unweighted and weighted index numbers using (i) aggregate method, (ii) average of price or quantity relative method (A.M. or G.M. is to be used as an average). Index numbers using; Laspeyre's, Paasche's and Fisher's formula. Tests of index numbers: unit test, time reversal test and factor reversal test. Cost of living index number: definition, problems in construction. Uses of index numbers.

Time Series: Meaning and need of time series analysis, components of time series, additive and multiplicative model, utility of time series. Methods of determining trends.

**Unit-3**

Statistical quality control: Meaning and purpose of Statistical quality control, Concept of process control, product control, assignable causes, chance causes and rational subgroups. ISO standards.

Control charts and their uses, Choice of subgroup sizes, Construction of control chart for $\overline{X}$ (mean), *R* (range), ***s*** (standard deviation),***c*** (no. of defectives), ***p*** (fraction defectives) with unequal subgroup size. Interpretation of non-random patterns of points. Modified control chart. CUSUM Chart. Consumer's risk, producer's risk, OC curve, acceptance sampling plan by attributes and variables. Concept of Six Sigma.

**References**


1. Srivastava, O.S. (1983) : A text book of demography. Vikas Publishing House, New Delhi.
2. Mukhopadhyay, P. (1994): Applied Statistics, new Central Book Agency Pvt. Ltd. Calcutta.
3. Goon A.M., Gupta M.K. and Das Gupta B. (1986): Fundamentals of Statistics, Vol. II, World Press, Calcutta.
4. Duncan A.J. (1974) : Quality Control and Industrial Statistics, IV Edision, Taraporewala and Sons.
5. Benjamin, B. (1959) : Health and vital statistics. Allen and Unwin
6. Chatfield C.: The Analysis of Time Series, IIndEdision Chapman and Hall.

| Course Code | STA 303 |
|---|---|
| Course Name | Theory of Attributes and Design of Experiments |
| Credit | 03 |

**Objective:**
The main objective is to introduce the notion of dependency of attributes and make students aware of designing and analysis of experiments.

**Learning Outcome:**

- Learn association between Attributes.
- Knowing Multiple and Partial correlation.
- Developing suitable experiments and analyse data to draw related inferences.

**Unit-1**

Theory of attributes: Independence and Association of attributes. Measures of association for two way classified data. Consistency and independence of data with special reference to attributes. Coefficient of colligation.

Multiple Correlation and Multiple regression and related results. Partial Correlation and related results.

**Unit-2**

Analysis of one way classified data. Analysis of two way classified data with one observation per cell. Analysis of two way classified data with *m* observations per cell. Analysis of two way classified data with unequal number of observations in cells under fixed effect model. Test for normality.

**Unit-3**

Basic terms in design of experiments: Experimental unit, treatment, layout of an experiment. Basic principles of design of experiments: Replication, randomization and local control. Choice of size and shape of a plot for uniformity trials, the empirical formula for the variance per unit area of plots.

Complete randomized design, randomized block design and Latin square design. Layout, model, assumptions and interpretations: Estimation of parameters, expected values of mean sum of squares, components of variance. Tests and their interpretations, test for equality of two specified treatment effects, comparison of treatment effects using critical difference (C.D.).
Factorial design $2^2$ and $2^3$. Missing Plan technique.

**References**


6. Cochran, W.G: Sampling Techniques, Wiley Eastern Ltd., New Delhi.
7. Sukhatme, P.V., Sukhatme, B.V. and Ashok A. : Sampling Theory of Surveys with Applications, Indian Society of Agricultural Statistics, New Delhi.
8. Murthy, M.N: Sampling Methods, Indian Statistical Institute, Kolkata.
9. Daroga Singh and Choudhary F.S.; Theory and Analysis of Sample Survey Designs,Wiley Eastern Ltd., New Delhi.
10. Mukhopadhay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

| Course Code | STA 304 |
|---|---|
| Course Name | Practical |
| Credit | 04 |
| Total hours | 45 |

**Objective:**

The main objective is to give exposure for the practical implementation of the topics learnt in this semester by using software

**Learning Outcome:**

- Formulation and solving problems using LPP
- computation of Demographic characteristics
- Awareness and use of Charts for SQ
- Analyses of data under different designs

1. Linear programming (graphical methods).
2. Simplex method.
3. Transportation problems.
4. Computation of various mortality and fertility rates.
5. Construction of life table and computation of expectation of life and force of mortality.
6. Construction of index numbers.
7. Tests for consistency of index numbers.
8. Construction of Consumer Price Index - interpretation.
9. Determination of secular trend by moving averages and least squares methods.
10. $\bar{X}$-R charts. (Standard values known and unknown)
11. np and p charts. (Standard values known and unknown).
12. Single sampling inspection plan by attributes
13. Analysis of CRD.
14. Analysis of $2^2$ factorial experiment using RBD layout.
15. Analysis of $2^3$ factorial experiment using RBD layout.
16. Analysis of $2^3$ factorial experiment using RBD layout. (Complete confounding)
17. Measures of association for two way classified data.
18. Multiple and partial correlation.

# SIXTH SEMESTER

| Course Code | STA 305 |
|---|---|
| Course Name | Operations Research |
| Credit | 03 |

**Objective:**

The main objective of this paper is to make students acquainted with the use of optimization techniques in decision making.

**Learning Outcome:**

- Understanding optimization through Linear Programming Problem.
- Knowing how to control Inventory statistically.
- Learning Game Theory.

**Unit-1**

Definitions and scope of operation research, different types of models in operations research - their construction and general method of solution.

Elements of linear programming problem (LPP): Canonical and standard forms, formulation of LPP, graphical method to solve two variable LPP, solution of LPP using simplex procedure, use of artificial variables in LPP, generation of extreme point solutions, principle of duality in LPP, statement and proof of duality theorem, simple problems based on duality theorem.

**Unit-2**

Allocation Models: Transportation problem (T.P.) different methods of finding initial feasible solution of a TP, UV method of finding optimal solution of a T.P., solution of assignment problem using Hungarian method. Formation of TP as LPP and its applications in routing problems and travelling salesman's problem.

Inventory Control: Definitions of various costs involved in inventory control. Deterministic Economic Lot Size problems with and without shortages.

**Unit-3**

Theory of games: Two person zero-sum games, pure and mixed strategies, saddle point, maximin-minimax principle of rectangular games, games without saddle point, dominance and modified dominance principles, graphical solution of 2xN and Mx2 games, reduction of game problems to a L.P.P.

**References**


1. Taha, H.A. (1999): Operations Research, Macmillan Publishing Company.
2. Hiller F.S. and Libermann G.J. (1995): Introduction to Operations Research, McGraw Hill.
3. Hadley G. (1965) : Linear programming, Addison Wesley.
4. Gass G.I. (1958): Linear Programming- Methods and Applications, McGraw Hill.
5. Mc Kinsey J.C.C. (1952): Introduction to the Theory and Games, McGraw Hill Book Co.
6. KantiSwaroop, Gupta P.K. and Singh M.M. (1985) : Operations Research, Sultan Chand and Sons.

| Course Code | STA 306 |
|---|---|
| Course Name | Reliability and Survival Analysis |
| Credit | 03 |
| Total hours | 45 |

**Objective:**
The main objective is to introduce different concepts and their interpretation in reliability and survival analysis.

**Learning Outcome:**

- Learning various statistical lifetime models.
- Understanding various classes and their interrelations.
- Non-parametric estimation in lifetime data.

**Unit-1**

Preliminaries: Definition and concept of time, event, Reliability/Survival function, Quantiles, hazard rate, cumulative hazard function and their relation with survival function mean residual life. Parametric models: Exponential, Weibull and normal and their survival characteristics.
Censoring mechanisms- type I, type II and left right and interval censoring. Likelihood function under censoring and related problems, Fitting parametric models to reliability/survival data with and without censoring.

**Unit-2**

Component and System and its Configuration, Structure function, Series Configuration, Parallel Configuration, *k* out of *n* structure, Series -Parallel Configuration, Parallel-Series Configuration. Reliability of coherent system and characteristics, Cuts and Path, modular decomposition, Basic ideas of accelerated life testing, IFR, IFRA, NBU, DMRL, NBUE classes and their duals.

**Unit-3**

Empirical survival function, Actuarial estimator, Kaplan-Meier estimators and its properties. Cox's proportional hazards model with one covariate and illustration based on survival data. Partial likelihood function and Properties, residuals in Cox regression model.

**References**


1. Deshpande, J.V. and Purohit, S. G.(2005): Life Time Data: Statistical Model and Methods, World Scientific.
2. Cox, D. R. and Oakes, D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
3. Sinha, S. K. and Kale, B. K. (1983): Life Testing and Reliability Estimation, Wiley Eastern Limited.
4. Elandt - Johnson, R.E. Johnson N. L.: Survival Models and Data Analysis, John Wiley and Sons.
5. Miller, R. G. (1981): Survival Analysis (John Wiley)

| Course Code | STA 307 |
|---|---|
| Course Name | Statistical Inference –II |
| Credit | 03 |

**Objective:**

The purpose is to enhance the existing knowledge of Point Estimation and Testing of Hypothesis and introduce the concept of Interval Estimation.

**Learning Outcome:**

- Understanding Cramer Rao inequality, Rao Blackwell theorem, Lehmann - Scheffe theorem.
- Learning the concept of MVBUE, MVUE, UMVUE.
- Knowledge of construction of MP test and UMP test.
- Knowledge of GLRT
- Knowledge of Interval Estimation.

**Unit-1**

Statement and proof of Cramer Rao inequality. Definition of Minimum Variance Bound Unbiased Estimator (MVBUE) of $\phi(\theta)$, (statement only). Rao-Blackwell theorem, Lehmann-Scheffe theorem. Proof of the following results:

(i) If MVBUE exists for $\theta$ then MVBUE exists for $\phi(\theta)$, if $\phi(.)$ is a linear function.

(ii) If T is MVBUE for $\theta$ then T is sufficient for $\theta$. Examples and problems.

Definition of MVUE, Procedure to obtain MVUE (statement only), examples. Minimum Variance Unbiased Estimator (MVUE) and Uniformly Minimum Variance Unbiased Estimator (UMVUE), complete sufficient statistic and uniqueness of UMVUE whenever it exists.

**Unit-2**

Review of testing of hypothesis and examples of construction of MP test of level $\alpha$ for binomial, Poisson, uniform, exponential and normal models.

Testing for one sided and two sided alternatives: Power function of a test, Monotone likelihood ratio properties, definition of uniformly most powerful (UMP) level $\alpha$ test. Statement of the theorem to obtain UMP level $\alpha$ test for one-sided alternative. Illustrative examples.

Likelihood Ratio Test (LRT) and its properties: LRT for (i) mean and variance of normal population. (ii) The difference of two means and ratio of two variances of normal populations.

**Unit-3**

The need and the concept of confidence interval, Pivotal method of confidence interval, Confidence interval for proportion, mean and variance of normal distribution. Large sample Confidence interval.

**References**


1. George Casella, Roger L. Berger (2002), Statistical Inference, 2nd ed., Thomson Learning.
2. Mukhopadhyay P. (1996): Mathematical Statistics, New central Book Agency (P) Ltd. Calcutta.
3. Rohatgi, V.K. (1984): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern.
4. Goon, Gupta & Das Gupta (1991): An Outline of Statistical Theory, Vol. II, World Press.
5. Hogg, R.V. and Craig, A.T. (1971): Introduction to Mathematical Statistics, McMillan.

| PAPER CODE | STA 308 |
|---|---|
| PAPER NAME | Practicals |
| CREDIT | 03 |

**Objective:**

The main objective is to enhance the practical knowledge of an individual in statistical problem solving using Computer Software.

**Learning Outcome:**

- Estimation in survival analysis
- Estimation of population parameters and their efficiencies under different sampling schemes.
- Computation of lower bound for variance
- Inference related to normal models.

1. Plotting of survival function, hazard rate for probability distributions.
2. Kaplan-Meier Estimator.
3. Cox's proportional hazards model
4. Cox regression model
5. Simple random sampling with and without sampling
6. Stratified random sampling.
7. Systematic Sampling.
8. Cluster sampling
9. Ratio Method of Estimation.
10. Regression Method of Estimation.
11. Problems on MVBUE.
12. Power function of a test
13. LRT for mean and variance of normal population. Andthe difference of two means and ratio of two variances of normal populations.