B.Sc. (Hons.) COURSE IN STATISTICS

THREE-YEAR FULL-TIME PROGRAMME
SEMESTERS I to VI

SCHEME OF EXAMINATION
AND COURSE CONTENTS

University of Delhi
Delhi-110007

2011

Syllabus applicable for the students seeking admission to the
B.Sc. (Hons.) Statistics Course in the Academic Year 2011-2012.
# B.Sc. (HONOURS) STATISTICS
## SCHEME OF EXAMINATION

<table>
<thead>
<tr>
<th>Examination 2011 and onwards</th>
<th>Duration (hrs.)</th>
<th>Max. Marks</th>
<th>Internal Assessment*</th>
</tr>
</thead>
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### First Year: Semester I (July to December)

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<thead>
<tr>
<th>Paper STH 101:</th>
<th>Technical Writing and Communication in English</th>
<th>3</th>
<th>75</th>
<th>25</th>
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</thead>
<tbody>
<tr>
<td>Paper STH 102:</td>
<td>Calculus-I</td>
<td>3</td>
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<td>Paper STH 103:</td>
<td>Algebra-I</td>
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<td>Paper STH 104:</td>
<td>Probability and Statistical Methods-I</td>
<td>3</td>
<td>75</td>
<td>25</td>
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Statistics/ Computer Lab.:
- **Practical-I:** 4 100
  - comprising the following two parts:
    - Part A: Based on Papers STH 103 and STH 104
    - Part B: Introduction to Computer fundamentals and Electronic Spread sheet.

### Examination 2012 and onwards

### First Year: Semester II (January to May)

<table>
<thead>
<tr>
<th>Paper STH 201:</th>
<th>Calculus-II</th>
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<th>75</th>
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<tbody>
<tr>
<td>Paper STH 202:</td>
<td>Algebra-II</td>
<td>3</td>
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<tr>
<td>Paper STH 203:</td>
<td>Probability and Statistical Methods-II</td>
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<tr>
<td>Paper STH 204:</td>
<td>Applied Statistics-I</td>
<td>3</td>
<td>75</td>
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Statistics Lab.:
- **Practical-II:** 4 100
  - Based on Papers STH 202, STH 203 and STH 204

### Examination 2012 and onwards

### Second Year: Semester III (July to December)

<table>
<thead>
<tr>
<th>Paper STH 301:</th>
<th>Real Analysis</th>
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<tbody>
<tr>
<td>Paper STH 302:</td>
<td>Probability and Statistical Methods-III</td>
<td>3</td>
<td>75</td>
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<tr>
<td>Paper STH 303:</td>
<td>Applied Statistics- II</td>
<td>3</td>
<td>75</td>
<td>25</td>
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<tr>
<td>Paper STH 304:</td>
<td>Survey Sampling</td>
<td>3</td>
<td>75</td>
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Statistics Lab.:
- **Practical-III:** 4 100
  - Based on Papers STH 302, STH 303 and STH 304
<table>
<thead>
<tr>
<th>Second Year: Semester IV (January to May)</th>
<th>Duration (hrs.)</th>
<th>Max. Marks</th>
<th>Internal Assessment*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper STH 401: Numerical Analysis</td>
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<td>75</td>
<td>25</td>
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<tr>
<td>Paper STH 402: Probability and Statistical Methods-IV</td>
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<td>25</td>
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<tr>
<td>Paper STH 403: Operational Research</td>
<td>3</td>
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<tr>
<td>Paper STH 404: Computer Programming in C</td>
<td>3</td>
<td>75</td>
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<tr>
<td>Statistics/ Computer Lab.: Practical-IV:</td>
<td>4</td>
<td>100</td>
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<tr>
<td>comprising the following two parts:</td>
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<tr>
<td>Part-A: Based on Papers STH 401 and STH 402</td>
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<td>Part-B: Based on Paper STH 404</td>
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<tr>
<td>Total Marks for Semester I to Semester VI:</td>
<td>3000</td>
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Note 1: Each theory paper will carry 100 marks including 25 marks earmarked for Internal Assessment*.

Note 2: For each theory paper there shall be 5 lecture periods. Besides, there will be tutorial classes with the tutorial groups of students as per University guidelines.

Note 3: Simple Calculator is allowed in the examination of each theory Paper.

Note 4: Twelve (12) periods per week will be devoted to Practicals I, II, III, and IV. Sixteen (16) periods per week will be devoted to Practicals V and VI. (The periods to be suitably divided in the case when Practical Paper has been split in Parts A and B).

Note 5: There will be one batch of 15 students for practical classes.

Note 6: The examination in Part A and Part B of Practicals I, IV, V and VI will be of 50 marks each.

Note 7: In respect of Practicals II and III carrying 100 marks each, 15 marks will be allocated to the class record and 10 marks to the oral test.

Note 8: In respect of each Part of the Practicals I, IV, V and VI carrying 50 marks (for each part), 10 marks will be allocated to the record book and 5 marks to the oral test.

Note 9: The conduct and evaluation in respect of the Examination relating to the Practical Papers would be as per the general guidelines laid down by the University.

Note 10: Colleges are advised and encouraged to conduct Practicals on P.C.’s as far as possible.

Note 11: For conducting Practical Classes, at least two Laboratories should be provided along with qualified Laboratory Staff in each college.

Note 12: The 25% marks for Internal Assessment will be distributed in the following manner:

(a) Attendance: 10%

(b) Assignments (at least one): 10%

(c) Class Tests/Project Presentation: 5%
DETAILED COURSES OF READING
B.Sc. (HONS.) STATISTICS

Semester I: Examination 2011 and onwards

Paper STH 101: Technical Writing and Communication in English

Unit 1
Communication: Language and communication, differences between speech and writing, distinct features of speech, distinct features of writing.

Unit 2
Writing Skills; Selection of topic, thesis statement, developing the thesis; introductory, developmental, transitional and concluding paragraphs, linguistic unity, coherence and cohesion, descriptive, narrative, expository and argumentative writing.

Unit 3
Technical Writing: Scientific and technical subjects; formal and informal writings; formal writings/reports, handbooks, manuals, letters, memorandum, notices, agenda, minutes; common errors to be avoided.

SUGGESTED READINGS:

2. L. Hamp-Lyons and B. Heasely: Study Writing; A course in written English. For academic and professional purposes, Cambridge Univ. Press.

ADDITIONAL REFERENCE BOOKS:


Paper STH 102: Calculus-I

Differential Calculus: Limits of functions, continuous functions (ε and δ notations), properties of continuous functions, review of results on differentiation, Successive differentiation, Leibnitz rule, partial differentiation, Euler’s theorem on homogeneous functions; maxima and minima of functions of one and two variables, Constrained Optimisation techniques (with and without Lagrange multiplier) along with few problems. Jacobians, point of inflexion; asymptotes; concavity and convexity of functions, singular points, tracing of curves in Cartesian and polar forms.

Review of Differential Equations, equations reducible to linear forms and homogenous forms, exact differential equations, Integrating Factor, Equations of first order but not of the first degree, Equations solvable for p.y and x, Clairut’s Equation. Linear differential equations with constant coefficients, Operators, solution of nth order differential equation, Inverse operators, homogeneous linear equations, equations reducible to homogeneous form
SUGGESTED READINGS:


Paper STH 103: Algebra-I

Demoivre’s theorem (both integral and rational index). Expansion for $\cos n\theta$, $\sin n\theta$, $\tan n\theta$ in terms of powers of $\sin\theta$, $\cos\theta$ and $\tan\theta$. Expansion of $\sin^n\theta$, $\cos^n\theta$ in terms of sine and cosine of multiples of $\theta$. Expansion of $\tan(\theta_1+\ldots+\theta_n)$ in terms of elementary symmetric functions of $\tan\theta_1$, $\ldots$, $\tan\theta_n$. Summation of series and complex roots of unity.

Theory of equations, statement of the fundamental theorem of algebra and its consequences. Relation between roots and coefficients or any polynomial equations. Solutions of cubic and biquadratic equations when some conditions on roots of equations are given. Evaluation of the symmetric polynomials and roots of cubic and biquadratic equations.

Inequalities: Inequality of means, Holder’s inequality, Cauchy-Schwartz Inequality, Triangle inequality, Tchebychef inequality, Weierstrass Inequality.


Determinants of Matrices: Definition, properties and applications of determinants for 3rd and higher orders, evaluation of determinants of order 3 and more using transformations. Symmetric and Skew-symmetric determinants, Circulant determinants and Vandermonde determinants for nth order, Jacobi’s Theorem, product of determinants. Use of determinants in solution to the system of linear equations.

SUGGESTED READINGS:


Paper STH 104: Probability and Statistical Methods-I

Statistical Methods: Concepts of statistical population and sample from a population, quantitative and qualitative data, Nominal, ordinal and time series data, discrete and continuous data. Presentation of data by table and by diagrams, frequency distributions by histogram and frequency polygon, cumulative frequency distributions (inclusive and exclusive methods) and ogive. Bivariate data-scatter diagram, principle of least squares and fitting of polynomials and exponential curves.

Measures of location (or central tendency) and dispersion. Moments, measures of skewness and kurtosis, absolute moments and factorial moments, Inequalities concerning moments, Sheppard’s corrections. Theory of attributes: Consistency of data, conditions for consistency, independence and association of attributes, measures of association and contingency.
Probability Theory: Random experiments, sample point and sample space, event, algebra of events. Definition of Probability – classical and relative frequency approach to probability; Richard Von-Mises, and Kolmogorov’s approach to probability, merits and demerits of these approaches (only general ideas to be given), theorems on probability, conditional probability, independent events, Bayes theorem and its applications.

SUGGESTED READINGS:


STATISTICS/ COMPUTER LAB.:

Practical-I:
comprising the following two parts:
Part A: Based on Papers STH 103 and STH 104
Part B: Introduction to Computer fundamentals and Electronic Spread sheet.

Semester II: Examination 2012 and onwards

Paper STH 201: Calculus-II


Double Integrals, change of order of integration, transformation of variables, Beta and Gamma integrals and relationship between them.

Geometry: Pair of straight lines, Circle, derivation of equation of tangent, normal, polar and length of tangent from any external point. Conic sections: Equation of Parabola and associated theorems, Ellipse, eccentric angle, equation of Ellipse and its tangents and normal in terms of eccentric angle, Hyperbola in standard forms and their properties, real, conjugate and rectangular Hyperbola.

SUGGESTED READINGS:

Paper STH 202: Algebra-II


Sets ,binary relations. Definitions and examples of groups,abelian-groups, rings, integral domain, skew-field and fields ,vector spaces with illustrations, vector space with real scalars, linear combination of vectors, sub-spaces, linear span, bases and change of bases, dimensions, orthogonal vectors, orthogonal basis, Gram-Schmidt orthogonalisation process. Matrix differentiation.

SUGGESTED READINGS:


Paper STH 203: Probability and Statistical Methods-II

Random Variables: Discrete and continuous random variables, p.m.f , p.d.f , c.d.f. illustrations of random variables and its properties. Univariate transformations.

Expectation of random variable and its properties. Moments and cumulants, moment generating function. Cumulant generation function and characteristic function.

Standard discrete probability distributions: Degenerate, Binomial, Poisson, Geometric, Negative Binomial, Hypergeometric.

Standard continuous probability distributions: Normal, uniform, exponential, beta, gamma, Cauchy, Laplace.

SUGGESTED READINGS:


Paper STH 204: Applied Statistics-I

Index Numbers: Definition, construction of index numbers by different methods, Problems faced in their construction, criterion of a good index number-Test Theory-unit, time reversal, factor reversal and circular tests. Errors in the construction of index numbers. Chain and Fixed base index numbers. Base Shifting, Splicing and Deflating of index numbers. Cost of Living Index numbers- construction and uses. Wholesale Price Index and Index of Industrial Production.

Demand Analysis: Demand function, price and income elasticity of demand, nature of commodities, laws of supply and demand, Income distributions, Pareto – curves of concentration.

Utility and Production Functions: utility function, constrained utility maximisation, indifference curves, derivation of demand curve, production function, homogeneous production functions, Isoquant and Isocost curves, Elasticity of substitution, C.E.S. functions, Multiple production by monopolist, discriminating monopolistic form, multiplant form.

Application of integration in Economics: Given Elasticity of any function then how to find function, consumer surplus, producer surplus, learning curves, finding consumption function from M.P.C, finding profit function from M.R and M.C.

Mathematical Finance: Compound Interest, Discount and present value, Different types of annuities.

SUGGESTED READINGS:


STATISTICS LAB.: Practical-II:
Based on Papers STH 202, STH 203 and STH 204.
Semester III: Examination 2012 and onwards

Paper STH 301: Real Analysis

Real Analysis: Representation of real numbers as points on the line and the set of real numbers as complete ordered field. Bounded and unbounded sets, neighborhoods and limit points, supremum and infimum, derived sets, open and closed sets, sequences and their convergence, limits of some special sequences such as \( \frac{1}{n} \left( 1 + \frac{1}{n} \right) \) and \( n^{\frac{1}{2}} \) and Cauchy’s general principle of convergence, Cauchy’s first theorem on limits, monotonic sequences, limit superior and limit inferior of a bounded sequence.

Infinite series, positive termed series and their convergence, Comparison test, D’Alembert’s ratio test, Cauchy’s \( n^{th} \) root test, Raabe’s test. Gauss test and Maclaurin’s integral test. Leibnitz’s test for the convergence of alternating series, Absolute convergence and Conditional convergence of series.

Continuous functions, algebra of continuous functions, continuous functions and boundedness. Differentiability, Rolle’s theorem, Mean Value theorems. Taylor’s theorem with lagrange’s and Cauchy’s form of remainder. Taylor’s and Maclaurin’s series expansions of sin\( x \), cos\( x \), log (1+x).

SUGGESTED READINGS:


Paper STH 302: Probability and Statistical Methods – III


Bivariate Transformations-concept and examples in uniform, normal, exponential, beta, gamma and Cauchy distributions.

Variance stabilizing transformations-sin\(^{-1}\), square root, log and Fisher’s z. Bivariate normal distribution and its properties. Multivariate normal distribution, its marginal and conditional distributions.

Correlation and regression: Karl Pearson’s Coefficient of Correlation, lines of regression, Spearman’s Rank Correlation Coefficient. Intraclass correlation coefficient, Correlation Ratio. Multiple and partial correlation coefficients (for three variates only).

Limit Laws: Convergence in probability, almost sure convergence, convergence in mean square and convergence in distribution. Chebyshev’s inequality, WLLN, SLLN applications, De-Moivre-Laplace theorem, central limit theorem (C.L.T.) for i.i.d. variates, Liapunov theorem (without proof) and applications of C.L.T.

SUGGESTED READINGS:

Paper STH 303: Applied Statistics-II


Sampling Inspection Plans- Acceptance-Rejection and Acceptance-Rectification plans, concepts, Acceptance Quality level (AQL), Lot Tolerance Percent Defective (LTPD), Process Average Fraction Defective, Producer’s Risk, Consumer’s Risk, Average Outgoing Quality (AOQ), Average Outgoing Quality Limit (AOQL), Operating Characteristic (OC) curve, Average Sample Number (ASN) Curve and Average Amount of Total Inspection (ATI) Curve. Single Sampling Plan- Probability of Acceptance using hypergeometric distribution and its approximation to Poisson and binomial distributions, its OC, AOQ, ASN and ATI functions. Determination of n and c using different approaches.

Indian official Statistics: Present official statistical system in India relating to census and population; methods of collection of official statistics. Various agencies responsible for the data collection-C.S.O., N.S.S.O., office of Registrar General, their main functions and important publications.

SUGGESTED READINGS:

Paper STH 304: Survey Sampling


Basic sampling methods: Simple random sampling with or without replacement for the estimation of mean, total, proportion and ratio. $T_1$ and $T_2$ classes of Linear estimators and minimum variance. Determination of sample size. Probability proportional to size sampling (with replacement).


Non sampling errors. Sources, Hansen and Hurwitz technique.

SUGGESTED READINGS:

STATISTICS LAB.:

Practical III:
Based on Papers STH 302, STH 303 and STH 304.

Semester IV: Examination 2013 and onwards

Paper STH 401: Numerical Analysis

Numerical Analysis: Factorial with positive and negative index. Operators: Shift operator ($E$), forward difference ($\Delta$), backward difference ($\nabla$), central difference ($\delta$), average ($\mu$), differential ($D$) and inter-relations between them. Finite differences of order $n$, divided differences of order $n$ and interpolation. Newton’s forward, backward and divided difference interpolation formulae with error term. Lagrange’s interpolation formula. Central difference formulae: Gauss and Stirling’s formulae.


Numerical integration: Newton-Cote’s integration formula, Trapezoidal rule, Simpson’s one-third rule, Simpson’s three-eighth rule and Weddle’s rule with error term. Euler-Maclaurin’s summation formula. Stirling’s approximation to factorial $n$.
Solution of difference equations of first order with variable coefficients and linear difference equations with constant coefficients.

**SUGGESTED READINGS:**


**Paper STH 402: Probability and Statistical Methods- IV**

Order Statistics: Introduction, distribution of \( r \)th order statistic, joint distribution of \( r \)th and \( s \)th order statistics.

Sampling Distribution: Definitions of random sample, parameter and statistic, sampling distribution of a statistic, sampling distribution of sample mean, standard errors of sample mean and sample proportion. Sampling distributions of chi-square, \( t \) and \( F \) statistics. Distribution of sample correlation coefficient \( r \) when \( \rho = 0 \).

Tests of significance: Null and alternative hypotheses, level of significance and probabilities of Type I and Type II errors, critical region and \( p \)-value. Large sample tests, use of CLT for testing single proportion, difference of two proportions, single mean, difference of two means, standard deviation and difference of standard deviations. Tests of significance based on \( t \), \( F \) and Chi-square distributions.

**SUGGESTED READINGS:**


**Paper STH 403: Operational Research**

Introduction to OR: Phases of OR, model building and various types of OR Problems, Linear Programming: Models, graphical solution, simplex method and M-technique. Concept of duality, dual simplex method, post-optimality analysis.

Game Theory: Rectangular games; methods of solution: dominance method, modified dominance, Graphical solution and algebraic technique solution by L.P. Method.

Simulations: Simulation models, event-type simulation, generation of random phenomena, steps in simulation, application of simulation techniques.

SUGGESTED READINGS:


Paper STH 404: Computer programming in C


Control Statements, conditional statements, if.. else, Nesting of if .... else, else if ladder, switch statements. Loops in C : for, while, do ... while loops. break, continue, exit( ), goto and label declarations. One dimensional, two dimensional and multidimensional arrays.

Functions, classification of functions, functions definition and declaration, accessing a function, return statement. Operations using string functions. Parameter passing in functions, recursion in Functions.

Storage classes: Automatic variables, External variables, static variables, register variables, Scope and lifetime of variables.

Pointers; Pointer Notation: and * operators. Pointer declaration and Initialization, Accessing a variable through pointer, pointer expressions, pointer arithmetic. Pointers and Arrays: Pointers and one dimensional arrays, dynamic memory allocation. Function returning pointers (single variable and one-dimensional arrays).


Preprocessors: Introduction to preprocessors, #define and #include.

SUGGESTED READINGS:

STATISTICS/ COMPUTER LAB.:  
Practical-IV:  
comprising the following two parts:  
Part-A: Based on Papers STH 401 and STH 402  
Part-B: Based on Paper STH 404  

Semester V: Examination 2013 and onwards  

Paper STH 501: Statistical Inference-I  
Interval estimation: Confidence intervals for the parameters of various distributions. Confidence intervals for difference of means and for ratio of variances. Confidence interval for binomial proportion and population correlation coefficient when population is normal. Pivotal quantity method of constructing confidence interval. Large sample confidence intervals.  

SUGGESTED READINGS:  

Vital Statistics: Sources of collecting data on vital statistics and errors encountered therein- Census, Registration, Adhoc surveys, hospital records. Mortality- CDR, SDR, STDR, IMR, along with their merits and demerits, Life Tables- construction of a complete life table along with assumptions and uses. Concept of an Abridged Life Table. Measurements of Fertility- CBR, GFR, SFR, TFR (merits and demerits). Measures of Population growth- Crude Rate of Natural Growth, GRR and NRR.  
Demography: Vital index, graduation of mortality rates by Gompertz and Makehm’s laws, Logistic curve, its fitting by the methods of (i) three selected points,(ii) Pearl and Reeds and (iii) Rhodes, its uses in population projection.  
Educational and Psychological Statistics: Scaling individual test items in terms of difficulties, Z-scores, Standard scores, Normalized score, T-scores, percentile scores. Scaling of rankings and ratings in
terms of Normal probability, Methods for determining test reliability, Validity of test scores and its
determination. IQ-its measurement and uses.

SUGGESTED READINGS:


Paper STH 503: Linear Models

General Linear models, estimability and BLUE, method of least squares, Gauss- Markoff theorem, estimation of error variance, distribution of quadratic forms for standard normal variates, tests of linear hypothesis.

Analysis of variance: One-way and two-way classified data with m (≥ 1) observations per cell for fixed effects models. Analysis of Covariance: One-way and two-way classified data with one concomitant variable.


SUGGESTED READINGS:


Paper STH 504: Stochastic Processes

Definition, classification and illustrative examples of stochastic processes, Mean value function and covariance Kernel, Probability generating function, Bivariate probability generating function, Convolution
and compound distribution, recurrent events, random walk model, absorbing and reflecting barriers, first passage probabilities and Gambler’s ruin problem, Discrete branching process, extinction probabilities, Markov chain-definition and examples, Chapman Kolmogorov’s equations and m-step transition probabilities, classification of states, closures and closed sets.

Poisson process and its applications- Pure Birth Process, Pure Death Process, Birth and Death process, Introduction to queuing theory, M/M/1 Queue with infinite waiting space. Yule Furry Process and Linear growth process.

SUGGESTED READINGS:

STATISTICS/ COMPUTER LAB.:
Practical-V
comprising the following two parts:
Part-A: Based on Papers STH 501, STH 502 and STH 503
Part-B: Introduction to Statistical Software/ Packages

Semester VI: Examination 2014 and onwards

Paper STH 601: Statistical Inference-II


SUGGESTED READINGS:


**Paper STH 602: Design of Experiments**

Experimental designs: Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, fertility contour maps, choice of size and shape of plots and blocks.

Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) – layout, model and statistical analysis, relative efficiency, analysis with missing observations.

Incomplete Block Designs: Balanced Incomplete Block Design (BIBD) – parameters, relationships among its parameters, incidence matrix and its properties, Symmetric BIBD, Resolvable BIBD, Affine Resolvable BIBD, Intra Block analysis, complimentary BIBD, Residual BIBD, Dual BIBD, Derived BIBD.

Factorial experiments: advantages, notations and concepts, $2^2$, $2^3$…$2^n$ and $3^2$ factorial experiments, design and analysis, Total and Partial confounding for $2^n (n \leq 5)$, $3^2$ and $3^3$. Factorial experiments in a single replicate.

Fractional factorial experiments: Construction of one-half and one-quarter fractions of $2^n (n \leq 5)$ factorial experiments, Alias structure, Resolution of a design.

**SUGGESTED READINGS:**


**Paper STH 603: Econometrics**


**SUGGESTED READINGS:**

Paper STH 604: Bio-Statistics

Functions of survival time, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, death density function for a distribution having bath-tub shape hazard function.

Type I, Type II and progressive or random censoring with biological examples. Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Actuarial and Kaplan-Meier methods.


Stochastic epidemic models: Simple and general epidemic models (by use of random variable technique). Duration of an epidemic.

Planning and design of clinical trials, Phase I, II and III trials. Blindings single, double and triple. Consideration in planning a clinical trial.

SUGGESTED READINGS:

STATISTICS/ COMPUTER LAB.: 
Practical-VI
comprising the following two parts:
Part A: Based on Papers STH 601, STH 602, STH 603 and STH 604
Part B: Problem solving using Statistical Software/Packages