Department of Mathematics and Statistics

Central University of Punjab, Bathinda

Course Scheme & Syllabus

for

M.Sc. Statistics

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017
### Scheme of Programme for M.Sc. Statistics

#### SEMESTER I

<table>
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Interdisciplinary courses offered by STA Faculty (For students of other Departments)

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$C_A$: Continuous Assessment: Based on Objective Type Tests (10%) / Assignments (5%)/Term Paper (10%)

$M_1$: Mid-Term Test-1: Based on Subjective Type Questions (25%)

$M_2$: Mid-Term Test-2: Based on Subjective Type Questions (25%)

$E_T$: End-Term Exam (Final): Based on Objective Type Questions (25%)

$T_M$: Total Marks

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## Scheme of Programme for M.Sc. Statistics
### SEMESTER II

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### Interdisciplinary courses offered by STA Faculty (For students of other Departments)

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$C_A$: Continuous Assessment: Based on Objective Type Tests (10%) / Assignments (5%)/Term Paper (10%)

$M_1$: Mid-Term Test-1: Based on Subjective Type Questions (25%)

$M_2$: Mid-Term Test-2: Based on Subjective Type Questions (25%)

$E_T$: End-Term Exam (Final): Based on Objective Type Questions (25%)

$T_M$: Total Marks

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Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017
### Scheme of Programme for M.Sc. Statistics
#### SEMESTER III

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Interdisciplinary elective
**: STA.611 is compulsory with STA.610 and STA.613 is compulsory with STA.612.

### Scheme of Programme for M.Sc. Statistics

#### SEMESTER IV

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**STA.621 is compulsory with STA.620.
Course Title: Probability and Distribution Theory
Course Code: STA.506
Total Hours: 60

Objectives:
The course is designed to equip the students with knowledge of various probability distributions and to develop greater skills and understanding of various inequalities for further studies.

Unit I  
(14 Lecture Hours)
Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability, combinatorial problems. Axiomatic approach to probability. Product sample spaces, conditional probability, Bayes’ formula.

Unit II  
(16 Lecture Hours)

Unit III  
(15 Lecture Hours)
Bivariate random variable and their joint, marginal and conditional p.m.f.s. and p.d.f.s, correlation coefficient, conditional expectation. Bivariate normal distributions. Moment generating and probability generating functions. Functions of random variables and their distributions using Jacobian of transformation and other tools. Probability Integral transformation, order statistics and their distributions (continuous case only), truncated distributions, compound distributions.

Unit IV  
(14 Lecture Hours)

Recommended Books:

Suggested Readings:
Course Title: Real Analysis
Course Code: STA.507
Total Lectures: 60

Objective: The aim of this course is to make the students learn fundamental concepts of metric spaces, Riemann-Stieltjes integral as a generalization of Riemann Integral, Sequence and series of functions and some basic theorems.

Unit-I (15 Lecture Hours)
- **Set Theory**: Finite, countable and uncountable sets
- **Metric spaces**: Definition and examples, Open and closed sets, Compact sets, Elementary properties of compact sets, k-cells, Compactness of k-cells, Compact subsets of Euclidean space $\mathbb{R}^k$, Perfect sets, Cantor set, Separated sets, Connected sets in a metric space, Connected subsets of real line.

Unit-II (15 Lecture Hours)
- **Sequences in Metric spaces**: Convergent sequences, Subsequences, Cauchy sequences, Complete metric space, Cantor’s intersection theorem, Category of a set and Baire’s category theorem. Examples of complete metric space, Banach contraction principle.

Unit-III (15 Lecture Hours)
- **Continuity**: Limits of functions (in Metric spaces), Continuous functions, Continuity and compactness, Continuity and connectedness, Discontinuities, Monotonic functions, Uniform continuity.
- **Riemann Stieltje’s Integral**: Definition and existence of Riemann Stieltje’s integral, Properties of integral. Integration and Differentiation. Fundamental Theorem of Calculus, 1st and 2nd Mean Value Theorems of Riemann Stieltje’s integral.

Unit-IV (15 Lecture Hours)
- **Sequences and series of functions**: Problem of interchange of limit processes for sequences of functions, Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation, equicontinuous families of functions, Stone Weierstrass Theorem.

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017
Course Title: Statistical Methods with Packages

Course Code: STA.508

Total Hours: 45

Objectives:
The course is designed to equip the students with various techniques used in summarization and analysis of data and also to give understanding of testing of hypotheses, some important distributions and also non-parametric tests for practical knowledge.

Unit I  (12 Lecture Hours)
Descriptive Statistics: Meaning, need and importance of statistics. Attributes and variables. Measurement and measurement scales. Collection and tabulation of data. Diagrammatic representation of frequency distribution: histogram, frequency polygon, frequency curve, ogives, stem and leaf plot, pie chart. Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 tables. Linear regression and correlation (Karl Pearson’s and Spearman’s) and residual plots.

Unit II  (12 Lecture Hours)
Normal, Chi-square, t and F distributions and their relations. Population, random sample, parameter, statistic and sampling distribution. Sample mean and sample variance associated with a random sample from a normal distribution: their independence, sampling distributions, expectations and standard errors. Fitting of Binomial, Poisson and Normal distribution.

Unit III  (11 Lecture Hours)
Statistical hypotheses, Type I and II errors, level of significance, test of significance, concept of p-value. Tests of significance for the parameters of normal distribution (one sample and two sample problems) and the relevant confidence intervals. Chi-square test of goodness of fit and independence of attributes. Test of significance for correlation coefficient ($\rho = 0, \rho = \rho_0$) (one and two sample problem).

Unit IV  (10 Lecture Hours)

Recommended Books:

Suggested Readings:
Course Title: Statistical Methods with Packages (LAB)
Course Code: STA.509
Total Hours: 30

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Topics should include graphic representation of data, descriptive statistics, correlation, linear regression and non-parametric tests.
Course Title: Linear Algebra
Course Code: STA.510
Total Hours: 60

Objective:
The concepts and techniques from linear algebra are of fundamental importance in many scientific disciplines. The main objective is to introduce basic notions in linear algebra that are often used in mathematics and other sciences. The emphasis will be to combine the abstract concepts with examples in order to intensify the understanding of the subject.

Unit I (15 Lecture Hours)
Vector Space: Vector spaces, Subspaces, Direct sum of subspaces, Linear dependence and independence, Basis and dimensions, Linear transformations, Algebra of linear transformations, Matrix representation of a linear transformation, Rank and nullity of a linear transformation, Invariant subspaces. Change of basis,

Unit I (16 Lecture Hours)
Characteristic polynomial and minimal polynomial of a linear transformation, Cayley Hamilton theorem, Eigenvalues and eigenvectors of a linear transformation, Diagonalization and triangularization of a matrix, Characteristic polynomial and minimal polynomial of block matrices. Canonical forms, Diagonal forms, Triangular forms, Jordan canonical forms, rational canonical forms, Quotient spaces.

Unit III (15 Lecture Hours)
Linear functional, Dual space, Dual basis, Annihilators, Bilinear forms, Symmetric bilinear forms, Sylvester’s theorem, quadratic forms, Hermitian forms. Reduction and classification of quadratic forms.

Unit IV (14 Lecture Hours)
Inner product spaces. Norms and distances, Orthonormal basis, Orthogonality, Schwartz inequality, The Gram-Schmidt orthogonalization process. Orthogonal and positive definite matrices. The Adjoint of a linear operator on an inner product space, Normal and self-adjoint operators, Unitary and orthogonal operators,

Recommended Books:
2. V. Bist and V. Sahai, Linear Algebra, Narosa, Delhi, 2002.

Suggested Readings:
Course Title: Actuarial Statistics
Course Code: STA.511
Total Hours: 60

Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of actuarial science and different premium models.

Unit I (16 Lecture Hours)
Probability Models and Life Tables, Loss distributions: modelling of individual and aggregate losses, moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance. Risk models: models for individual claims and their sums, Distribution of aggregate claims, Compound distributions and applications, Introduction to credibility theory.

Unit II (14 Lecture Hours)
Survival function, curtate future lifetime, force of mortality. Multiple life functions, joint life and last survivor status. Multiple decrement model.

Unit III (14 Lecture Hours)
Life Contingencies: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor.

Unit IV (16 Lecture Hours)
Assurance and annuity contracts: definitions of benefits and premiums, various types of assurances and annuities, present value, formulae for mean and variance of various continuous and discrete payments. Calculation of various payments from life tables: principle of equivalence, net premiums, prospective and retrospective provisions/reserves.

Recommended Books:

Suggested Readings:
Course Title: Basic Statistics
Course Code: STA.503
Total Hours: 30

Objectives:
To provide the understanding and use of Statistical techniques for students of other departments.

Unit I  
(7 Lecture Hours)

Unit II  
(8 Lecture Hours)
Measures of central tendency, dispersion (including box and whisker plot), skewness and kurtosis. Data on two attributes, independence and association of attributes in 2x2 tables. Linear regression and correlation (Karl Pearson’s and Spearman’s) and residual plots.

Unit III  
(7 Lecture Hours)
Random experiments, sample spaces (finite and infinite), events, algebra of events, three basic approaches to probability, combinatorial problems. Axiomatic approach to probability. Product sample spaces, conditional probability, Bayes’ formula.

Unit IV  
(8 Lecture Hours)

Recommended Books:

Suggested Readings:
Semester II

Course Title: Computer Fundamentals and C Programming
Course Code: STA.521
Total Hours: 45

Objectives: The aim of this course is to provide adequate knowledge of fundamentals of computer along with problem solving techniques using C programming. This course provides the knowledge of writing modular, efficient and readable C programs. Students also learn the utilization of arrays, structures, functions, pointers, file handling and their applications.

Unit-I (10 Lecture Hours)

Computer Hardware: Definitions, Historical overview, Technological advancement in computers, Shape of today’s computer, Computer as a system. CPU, Primary memory, Secondary storage devices, Input and Output devices,

Unit-II (11 Lecture Hours)

Computer Software: Significance of software in computer system, Categories of software – System software, Application software, Compiler, Interpreter, Utility program, Binary arithmetic for integer and fractional numbers, Operating System and its significance. Introduction to algorithm, Flow charts, Problem solving methods, Need of programming languages.

Unit-III (12 Lecture Hours)

C Programming: Historical development of C, C character set, Identifiers and keywords, Data types, Declarations, Statement and symbolic constants, Input-output statements, Preprocessor commands, Operators, Expressions, Library functions, Decision making and loop control statements

Unit-IV (12 Lecture Hours)

C Programming: Functions, Storage Classes, Arrays, Strings, Pointers, Structure and Union, File handling.

Recommended Books:

Suggested Readings:
Course Title: Computer Fundamentals and C Programming (LAB)
Course Code: STA.522
Total Hours: 30

Laboratory experiments will be set in context with the materials covered in the theory.
Course Title: Estimation and Testing of Hypotheses
Course Code: STA.523
Total Hours: 45

Objectives:
The concepts and techniques of estimation and testing of hypothesis are of great importance in statistics. The main objective is to introduce estimation as well as introduction to hypothesis testing in practical life.

Unit I  (10 Lecture Hours)

**Estimation:** Introduction to the problem of estimation. Concepts of unbiasedness, sufficiency, consistency, efficiency, completeness.


Unit II  (11 Lecture Hours)


**Tests of Hypotheses:** Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. Most Powerful (MP) and Uniformly Most Powerful (UMP) tests in a class of size $\alpha$ tests.

Unit III  (12 Lecture Hours)

Neyman - Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. Extension of these results to Pitman family when only upper or lower end depends on the parameter and to distributions with MLR property. Non-existence of UMP test for simple null against two-sided alternatives in one parameter exponential family. Likelihood Ratio Tests. Wald’s SPRT with prescribed errors of two types.

Unit IV  (12 Lecture Hours)

**Interval estimation:** Confidence interval, confidence level, construction of confidence intervals using pivots, shortest expected length confidence interval, uniformly most accurate one sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypotheses. Tests of hypotheses and interval estimation viewed as decision problems with given loss functions.

Recommended Books:

Suggested Readings:

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Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Measure Theory
Course Code: STA.525
Total Hours: 60

Objective: The objective of this course is to introduce student’s measure theory in an abstract setting after having studied Lebesgue measure on real line. Some important theorems are also studied.

Unit-I (15 Lecture Hours)
Semi-algebras, Algebras, Monotone class, $\sigma$ -algebras, Measure and outer measures, Caratheödory extension process of extending a measure on semi-algebra to generated $\sigma$ -algebra, Completion of a measure space.

Unit-II (15 Lecture Hours)

Unit-III (15 Lecture Hours)
Measurable functions on a measure space and their properties, Borel and Lebesgue measurable functions, Simple functions and their integrals, Littlewood’s three principle and Egoroff’s Theorem (statement only), Lebesgue integral on R and its properties.

Unit-IV (15 Lecture Hours)
Bounded convergence theorem, Fatou’s lemma, Lebesgue monotone convergence theorem, Lebesgue dominated convergence theorem, $L^p$ spaces, Young’s inequality, Minkowski’s and Hölder’s inequalities, Riesz-Fischer theorem (statement only).

Recommended Books:

Suggested Readings:
Course Title: Stochastic Processes
Course Code: STA.526
Total Hours: 60

Objectives:
This course is framed to equip the students of M.Sc. Statistics with knowledge of different processes, stationarity as well as basic knowledge of this course.

Unit I (15 Lecture Hours)

Unit II (15 Lecture Hours)

Unit III (15 Lecture Hours)

Unit IV (15 Lecture Hours)

Recommended Books:

Suggested Readings:
Course Title: Complex Analysis

Course Code: STA.527

Total Lectures: 60

Objective: This course is aimed to provide an introduction to the theories for functions of a complex variable. It begins with the exploration of the algebraic, geometric and topological structures of the complex number field. The concepts of analyticity, Cauchy-Riemann equations and harmonic functions are then introduced. Students will be equipped with the understanding of the fundamental concepts of complex variable theory.

Unit-I  
(15 Lecture Hours)
Review of complex number system, Algebra of complex numbers, Complex plane, Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic function, Cauchy- Riemann equations, Harmonic functions and Harmonic conjugate.

Unit-II  
(15 Lecture Hours)
Complex line integral, Cauchy’s theorem, Cauchy-Goursat theorem, Cauchy’s integral formula and its generalized form, Index of a point with respect to a closed curve, Cauchy’s inequality. Poisson’s integral formula, Morera’s theorem. Liouville’s theorem, Contour integral, Power series, Taylor’s series, Higher order derivatives, Laurent’s series.

Unit-III  
(15 Lecture Hours)
Singularities of analytic functions, Fundamental theorem of algebra, Zeroes of analytic function, Poles, Residues, Residue theorem and its applications to contour integrals, Branches of many valued functions with arg z, log z, and z^a. Maximum modulus principle, Schwarz lemma, Open mapping theorem.

Unit-IV  
(15 Lecture Hours)
Meromorphic functions, The argument principle, Rouche’s theorem, Mobius transformations and their properties and classification, Definition and examples of conformal mappings.

Recommended Books:

Suggested Readings:
Course Title: Linear Models and Regression
Course Code: STA.528
Total Hours: 30

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Objectives:
The concepts and techniques from linear models are of fundamental importance in statistics. The main objective is to introduce estimator in linear models. The emphasis will also be upon the testing of linear hypothesis, linear and non-linear models to intensify the understanding of the subject.

Unit I (7 Lecture Hours)
Point and interval estimates, best linear unbiased estimates, construction of confidence intervals of the parameters of linear model.

Unit II (8 Lecture Hours)
Gauss-Markoff set-up, normal equations, least squares estimates and their precision, use of g-inverse, statements and applications of fundamental theorems of least squares.

Unit III (7 Lecture Hours)
Introduction to fixed, mixed and random effect models. Tests of significance and interval estimates based on least squares theory in one-way and two-way classified data.

Unit IV (8 Lecture Hours)
Bivariate, Multiple and polynomials regression and use of orthogonal polynomials. Residuals and their plots as tests for departure from assumptions of fitness of the model normality, homogeneity of variances. Analysis of variance (ANOVA) and analysis of covariance (ANCOVA).

Recommended Books:

Suggested Readings:
Course Title: Basics of Inferential Statistics
Course Code: STA.504

Total Hours: 30

Objectives:
The course will help students from other stream like Microbiological Sciences, Plant Sciences, Animal Sciences etc. to understand testing of hypotheses concept in easy manner. The main objective is to give basic understanding of testing of hypothesis to science students so that they can frame correct Hypothesis in their research work and both parametric and non-parametric tests help them to draw conclusions from the sample.

Unit I  
(7 Lecture Hours)

Unit II  
(8 Lecture Hours)
Meaning of parameters, test statistic and their sampling distributions. Need of Inferential Statistics.
Estimation: Point Estimation and Confidence Interval. Testing of Hypothesis: Simple and Composite Hypothesis, Type I error, Type II error, power, level of significance, acceptance region, rejection region, confidence interval.

Unit III  
(7 Lecture Hours)
Parametric tests: Test for parameters of Normal population (one sample and two sample problems) z-test, student’s t-test, F and chi-square test and Analysis of Variance (ANOVA).

Unit IV  
(8 Lecture Hours)

Recommended Books:
4. Suggested Readings:
Semester III

Course Title: Research Methodology
Course Code: STA.502

Total Hours: 30

Objectives: The objective of this course is to equip the students with knowledge of some basic as well as advanced concepts related to research. The course covers preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism etc.

Unit-I  
(7 Lecture Hours)


Unit-II  
(8 Lecture Hours)

Literature Survey and Review: Meaning of Literature Survey and Review, Sources of Literature, Methods of Literature Review, and Techniques of Writing the Reviewed Literature. 

Unit-III  
(7 Lecture Hours)


Unit-IV  
(8 Lecture Hours)


Recommended Books:

3. Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017

**Course Title:** Multivariate Analysis  
**Course Code:** STA.551  
**Total Hours:** 45  
**Objectives:**

This course is framed to equip the students of M.Sc. Statistics with knowledge of multivariate analysis.

**Unit I**  
(11 Lecture Hours)


**Unit II**  
(12 Lecture Hours)

Null distribution of Hotelling’s $T^2$ Statistic. Application in tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Mahalanobis $D^2$ and its sampling distribution.

**Unit III**  
(11 Lecture Hours)


**Unit IV**  
(11 Lecture Hours)


**Recommended Books:**

**Suggested Readings:**
Course Title: Multivariate Analysis (LAB)
Course Code: STA.552
Total Hours: 30
Laboratory experiments will be set in context with the materials covered in theory.

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Total Hours: 45

Objectives:
The course is designed to equip the students with basic knowledge of different sampling schemes, their mean and variance estimations and also give understanding of non-sampling errors.

Unit I  (11 Lecture Hours)
Introduction to usual notations used in sampling. Basic finite population sampling techniques: SRSWOR, SRSWR, stratified, systematic and related results on estimation of population mean/total. Relative precision of different sampling techniques. Allocation problem in stratified sampling.

Unit II  (12 Lecture Hours)
Ratio and regression estimators based on SRSWOR method of sampling. Two-stage sampling with equal size of first stage units. Double sampling for ratio and regression methods of estimation. Cluster sampling - equal clusters.

Unit III  (12 Lecture Hours)
PPS WR/WOR methods [cumulative total, Lahiri’s schemes] and related estimators of a finite population mean: [Thompson-Horwitz, Yates and Grundy estimator, Desraj estimators for a general sample size and Murthy’s estimator for a sample of size 2].

Unit IV  (10 Lecture Hours)
Sampling and Non-sampling errors with special reference to non-response problems. National sample surveys office (NSSO) and role of various statistical organizations in national development.

Recommended Books:

Suggested Readings:
Course Title: Sampling Theory (LAB)
Course Code: STA.554
Total Hours: 30

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Experiments based on various sampling techniques and comparison in appropriate practical situations.
Course Title: Quality Control and Time series
Course Code: STA.555
Total Hours: 45

Objectives:
This course is framed to equip the students of M.Sc. Statistics with knowledge of industrial statistics as well as application of Time series in our practical life.

Unit I (11 Lecture Hours)
The meaning of quality, quality assurance, technology and productivity. Statistical methods for quality control and improvement. Chance and assignable causes of quality variation, general theory of control charts, control charts for variables: $\bar{X}$ and R chart, analysis of pattern on control charts, control chart for attributes- np, p, c and u charts.

Unit II (11 Lecture Hours)
Multiple stream processes: Group control charts. Specification limits and tolerance limits, O.C and ARL of control charts, CUSUM charts using V-mask and decision intervals, economic design of (Mean) chart.

Unit III (12 Lecture Hours)
Review of sampling inspection techniques, single, double, multiple and sequential sampling plans and their properties, methods for estimating (n, c) using large sample techniques, curtailed and semi-curtailed sampling plans, Dodge’s continuous sampling inspection plans for inspection by variables for one-sided and two-sided specifications.

Unit IV (11 Lecture Hours)

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017
Course Title: Quality Control and Time Series (LAB)  
Course Code: STA.556  
Total Hours: 30

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Topics should include problems of Quality Control and Time Series using SPSS.
Course Title: Seminar  
Course Code: STA.597  
Total Hours: 60

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Total Hours: 60
Course Title: Operations Research
Course Code: STA.557
Total Hours: 60

Objective:
The objective of this course is to acquaint the students with the concept of convex sets, their properties, Linear and nonlinear programming problems. The results, methods and techniques contained in this paper are very well suited to the realistic problems in almost every area.

Unit-I (15 Lecture Hours)
Mathematical formulation of linear programming problem, Linear Programming and examples, Convex Sets, Hyper plane, Open and Closed half-spaces, Feasible, Basic Feasible and Optimal Solutions, Extreme Point & graphical methods. Simplex method, Big-M method, Two phase method, Determination of Optimal solutions, Unrestricted variables.

Unit-II (15 Lecture Hours)

Unit-III (15 Lecture Hours)

Unit -IV (15 Lecture Hours)
Replacement problem, replacement of items that Deteriorate, replacement of items that fail completely. Job Sequencing Problems; Introduction and assumption, Processing of n jobs through two machines, Processing of n jobs through three machines and m machines, Processing two jobs through n machines.

Recommended books:

Suggested Readings:
Course Title: Demography and Vital Statistics

Course Code: STA.55

Total Hours: 60

Objectives:
The course on Demography and Vital Statistics is framed to equip the students of M.Sc. Statistics with knowledge of terms and analysis of data related with vital events.

Unit I (15 Lecture Hours)
Population Theories: Coverage and content errors in demographic data, use of balancing equations and Chandrasekharan-Deming formula to check completeness of registration data, Adjustment of age data use of Myer and UN indices Population composition, dependency ratio.

Unit II (15 Lecture Hours)
Measures of fertility: stochastic models for reproduction, distribution of time to first birth, inter-live birth intervals and of number of births, estimation of parameters, estimation of parity progression ratio from open birth interval data.

Unit III (15 Lecture Hours)

Unit IV (15 Lecture Hours)

Recommended Books:

Suggested Readings:
Course Title: Reliability Theory
Course Code: STA.559
Total Hours: 60

Objectives:
The course on Reliability Theory is framed to equip the students of M.Sc. Statistics with knowledge of terms involved in reliability theory as well as concepts and measures.

Unit I  (15 Lecture Hours)
Reliability concepts and measures: Components and systems, coherent systems, reliability of coherent systems, cuts and paths, modular decomposition, bounds on system reliability, structural and reliability importance of components.

Unit II  (15 Lecture Hours)
Life distributions and associated survival, conditional survival and hazard rate functions. Exponential, Weibull, gamma life distributions and estimation of their parameters.

Unit III  (15 Lecture Hours)
Notions of ageing. IFR IFRA, NBU, DMRL, NBUE, and HNBUE classes; their duals and relationships between them. Closures of these classes under formation of coherent systems, convolutions and mixtures.

Unit IV  (15 Lecture Hours)
Partial orderings: Convex, star, stochastic, failure rate and mean-residual life orderings. Univariate shock models and life distributions arising out of them. Maintenance and replacement policies, availability of repairable systems.

Recommended Books:


Suggested Readings:

Course Title: Numerical Analysis
Course Code: STA.560

Total Hours: 45

Objective:
The aim of this course is to teach the applications of various numerical techniques for a variety of problems occurring in daily life. At the end of the course, the students will be able to do programming in C/C++/MATLAB and understand the basic concepts in Numerical Analysis of differential equations.

Unit-I  
(11 Lecture Hours)


Unit-II  
(12 Lecture Hours)

Polynomial Interpolation: Interpolating polynomial, Lagrange and Newton divided difference interpolation, Error in interpolation, Finite difference formulas, Hermite Interpolation.

Unit-III  
(11 Lecture Hours)

Spline and Approximation: Cubic Spline, Least square method, Pâde approximation
Eigen Value Problems: Power method.
Numerical Differentiation and Integration: Numerical differentiation with finite differences, Trapezoidal rule, Simpson's 1/3 - rule, Simpson's 3/8 rule, Error estimates for Trapezoidal rule and Simpson's rule, Gauss quadrature formulas.

Unit-IV  
(11 Lecture Hours)


Recommended Books:

Suggested Readings:
Course Title: Numerical Analysis (Lab)
Course Code: STA.561
Total Hours: 30

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Objective: Laboratory experiments will be set in context with the materials covered in theory in C/C++/MATLAB.

Laboratory Work: Programming exercises on numerical methods using C/C++/MATLAB languages.

1. To detect the interval(s) which contain(s) root of equation $f(x)=0$ and implement bisection method to find root of $f(x)=0$ in the detected interval.
2. To find the root of $f(x)=0$ using Newton-Raphson and fixed point iteration methods.
3. To compute the intermediate value using the Newton’s forward difference interpolation formula.
4. To compute Lagrange and divided difference interpolating polynomials.
5. To solve linear system of equations using Gauss elimination (without pivoting) method.
6. To solve linear system of equations using Gauss-Seidel method.
7. To find the dominant eigen-value and associated eigen-vector by Rayleigh power method.
8. To integrate a function numerically using trapezoidal and Simpson’s rule.
9. To solve the initial value problem using Euler and modified Euler’s methods.
10. To solve the initial value problem using and Runge-Kutta methods.
Course Title: Non-Parametric Inference  
Course Code: STA.562  
Total Hours: 60

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with non-parametric inference and its various tests. Various measure to measure risk will be studied in this course.

Unit I (15 Lecture Hours)

Unit II (15 Lecture Hours)

Unit III (15 Lecture Hours)

Unit IV (15 Lecture Hours)

Recommended Books:
5. Suggested Readings:
Course Title: Non-Parametric Inference (LAB)
Course Code: STA.563
Total Hours: 30

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Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Survival Analysis  
Course Code: STA.564  
Total Hours: 60

Objectives:
The course gives the application of statistics in handling survival data. The course introduces the concept of censoring and the various distributions used to analyses such data. Various models are also suggested to deal with survival data.

Unit I  
(15 Lecture hours)  
Concepts of Type-I (time), Type-II (order) and random censoring likelihood in these cases. Life distributions, exponential, gamma, Weibull, lognormal, Pareto, linear failure rate.

Unit II  
(15 Lecture hours)  
Inference for exponential, gamma, Weibull distributions under censoring. Failure rate, mean residual life and their elementary properties. Ageing classes and their properties, bathtub failure rate.

Unit III  
(15 Lecture hours)  
Estimation of survival function – Actuarial estimator, Kaplan –Meier estimator, Tests of exponentiality against non-parametric classes: Total time on Test, Deshpande Test.

Unit IV  
(15 Lecture hours)  
Two sample problem: Gehan test, Log rank test, Mantel-Haenszel test, Cox’s proportional hazards model, competing risks model.

Recommended Books:

Suggested Readings:
Semester IV

Course Title: Design and Analysis of Experiment
Course Code: STA.571
Total Hours: 45

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Objectives:
The course is designed to equip the students with various types of designs that are used in practical life and to develop greater skills and understanding of analysis of these designs.

Unit I (12 Lecture Hours)
Three basic principles of design of experiments: Randomization, replication and local control. Design useful for one-way elimination of heterogeneity. Completely randomized, randomized complete block and balanced incomplete block designs. Analysis of Basic Design: Asymptotic relative efficiency, Missing plot technique, Analysis of covariance for CRD and RBD.

Unit II (11 Lecture Hours)
Concepts of balancing, orthogonality, connectedness and properties of C-matrix. General inter and intra block analysis of incomplete block designs. $2^k$, $3^k$ factorial designs, fractional replication and split-plot designs. Design useful for two-way elimination of heterogeneity and their general method of analysis by using fixed effect model, Latin squares, Graeco Latin squares and Youden squares designs.

Unit III (11 Lecture Hours)
Missing plot techniques, illustrations of construction of $s \times s$ mutually orthogonal Latin squares and balanced incomplete block designs (by using finite geometries, symmetrically repeated differences and known B.I.B. designs).

Unit IV (11 Lecture Hours)

Recommended Books:

Suggested Readings:

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2017
Course Title: Design and Analysis of Experiment (LAB)
Course Code: STA.572
Total Hours: 30
Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Project Work
Course Code: STA.599
Total Hours: 120

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</table>
Course Title: Game Theory and Non-Linear Programming

Course Code: STA.573

Total Hours: 60

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of game theory as well as Non-linear Programming problem.

Unit I

Unit II

Unit III

Unit IV

Recommended Books:

Suggested Readings:
Course Title: Statistical Simulation
Course Code: STA.574
Total Hours: 60

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with knowledge of random number generation using congruential and Monte Carlo Methods as well as basic knowledge of this course.

Unit I  (16 Lecture Hours)

Unit II  (14 Lecture Hours)
Random Number Generation: Congruential generators, statistical tests for pseudo random numbers.

Unit III  (16 Lecture Hours)

Unit IV  (14 Lecture Hours)
Monte Carlo integration and variance reduction techniques : Hit or miss Monte Carlo method, sample mean Monte Carlo method, importance sampling, correlated sampling control variates, stratified sampling, antithetic variates, partition of region.

Recommended Books:

Suggested Readings:
Course Title: Advanced Numerical Analysis
Course Code: STA.575
Total Hours: 60
Objectives: The objective of the course is to familiarize the students about some advanced numerical techniques e.g. solving systems of nonlinear equations, linear system of equations, Eigen value problems, Interpolation and Approximation techniques and their use in differentiation and integration, differential equations etc.

UNIT- I

Non-Linear Equations: Methods for multiple roots, Muller’s, Iteration and Newton-Raphson method for non-linear system of equations, and Newton-Raphson method for complex roots.
Polynomial Equations: Descartes’ rule of signs, Birge-Vieta, Bairstow and Giraffe’s methods.
System of Linear Equations: Triangularization, Cholesky and Partition methods, SOR method with optimal relaxation parameters.

UNIT- II

Eigen-Values of Real Symmetric Matrix: Similarity transformations, Gerschgorin’s bound(s) on eigenvalues, Jacobi, Givens, Householder and Rutishauser methods.
Interpolation and Approximation: B - Spline and bivariate interpolation, Gram-Schmidt orthogonalisation process and approximation by orthogonal polynomial, Legendre and Chebyshev polynomials and approximation.

UNIT- III

Differentiation and Integration: Differentiation and integration using cubic splines, Romberg integration and multiple integrals.
Ordinary Differential Equations: Shooting and finite difference methods for second order boundary value problems, Applications of cubic spline to ordinary differential equation of boundary value type.

UNIT- IV


Recommended Books:

Suggested Readings:
Course Title: Econometrics
Course Code: STA.576
Total Hours: 45

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of econometrics as well as practical usage of this course.

Unit I  
(12 Lecture Hours)
Nature of econometrics. The general linear model (GLM) and its assumptions. Ordinary least squares (OLS) estimation and prediction. Significance tests and confidence intervals, linear restrictions. Use of dummy variables and seasonal adjustment. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances.

Unit II  
(12 Lecture Hours)

Unit III  
(10 Lecture Hours)

Unit IV  
(11 Lecture Hours)
Estimation in simultaneous equations model. Recursive systems. 2 SLS estimators, k-class estimators. 3SLS estimation. Full information maximum likelihood method. Prediction and simultaneous confidence intervals. Monte Carlo studies and simulation.

Recommended Books:

Suggested Readings:
Course Title: Econometrics (LAB)
Course Code: STA.577
Total Hours: 30

Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Investment Risk Analysis  
Course Code: STA.578  
Total Hours: 60

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of risk involved in investment. Various measure to measure risk will be studied in this course.

Unit I  
(15 Lecture Hours)

Unit II  
(15 Lecture Hours)

Unit III  
(15 Lecture Hours)

Unit IV  
(15 Lecture Hours)

Recommended Books:

Suggested Readings:
Course Title: Economic Statistics
Course Code: STA.579
Total Hours: 60

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with applications of statistics in economics. Various measure to measure risk will be studied in this course.

Unit I  
(15 Lecture Hours)
The theory of Consumer Behaviour: Utility function, indifference curves and their properties, price and income elasticities, substitution and income effects.

Unit II  
(15 Lecture Hours)

Unit III  
(15 Lecture Hours)

Unit IV  
(15 Lecture Hours)

Recommended Books:

Suggested Readings: