Central University of Punjab, Bathinda

Course Scheme & Syllabus

for

M.Sc. Statistics

Syllabi Applicable for Admissions in M. Sc. (Statistics), 2015
Syllabi Applicable for Admissions in M. Sc. (Statistics), 2015
### Scheme of Programme M.Sc. Statistics

#### SEMESTER I

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**Interdisciplinary courses offered by STA Faculty (For students of other Centres)**

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C_A: Continuous Assessment: Based on Objective Type Tests/ Assignments

M_1: Mid-Term Test-1: Based on Objective Type & Subjective Type Test

M_2: Mid-Term Test-2: Based on Objective Type & Subjective Type Test
$E_T$: End-Term Exam (Final): Based on Objective Type Tests

$T_M$: Total Marks

C: Core; $I_E$: Interdisciplinary elective; F: Foundation; L: Lectures; T: Tutorial; P: Practical; Cr: Credits.
# Scheme of Programme M.Sc Statistics

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### Scheme of Programme M.Sc Statistics

#### SEMESTER IV

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**C₂ : Continuous Assessment: Based on Objective Type Tests/ Assignments**

**M₁ : Mid-Term Test-1: Based on Objective Type & Subjective Type Test**

**M₂ : Mid-Term Test-2: Based on Objective Type & Subjective Type Test**

**Eₚ : End-Term Exam (Final): Based on Objective Type Tests**

**Tₘ : Total Marks**

C: Core; Iₜ : Interdisciplinary elective; F: Foundation; L: Lectures; T: Tutorial; P: Practical; Cr: Credits.
Course Title: Research Methodology - I  
Course Code: STA.401  
Total Hours: 32  

Objectives:  
The course Research Methodology - General has been framed to introduce basic concepts of Research Methods. The course covers preparation of research plan, reading and understanding of scientific papers, scientific writing, research proposal writing, ethics, plagiarism, laboratory safety issues etc.

Unit I  (8 Lecture Hours)  
Introduction: Meaning and importance of research, Different types and styles of research, Role of serendipity, Critical thinking, Creativity and innovation, Hypothesis formulation and development of research plan, Art of reading, understanding and writing scientific papers, Literature survey, Interpretation of results and discussion, Poster preparation and presentation.

Unit II  (8 Lecture Hours)  

Unit III  (8 Lecture Hours)  
Good Laboratory Practices: Recent updates on good laboratory practices. Laboratory Safety Issues: Lab, Workshop, Electrical, Health and fire safety, Safe disposal of hazardous materials.

Unit IV  (8 Lecture Hours)  
Intellectual Property Rights: Intellectual Property, intellectual property protection (IPP) and Intellectual property rights (IPR), WTO (Word Trade Organization), WIPO (Word Intellectual property organization). GATT (General Agreement on Traffic and Trade), TRIPS (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services), Nuts and Bolts of Patenting, Ethics and Values in IP.

Recommended Books:  
Syllabi Applicable for Admissions in M. Sc. (Statistics), 2015
Course Title: Statistical Methods with Packages  
Course Code: STA.502  
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 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 (10 Lecture Hours)

Unit III (11 Lecture Hours)

Unit IV (13 Lecture Hours)

Recommended Books:
Course Title: Statistical Methods with Packages (LAB)
Course Code: STA.503
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: Sampling Theory
Course Code: STA.504
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)
Basic ideas and distinctive features of sampling; Probability sampling designs, sampling schemes, inclusion probabilities and estimation; Review of important results in simple and stratified random sampling.

Unit II (12 Lecture Hours)

Unit III (12 Lecture Hours)
Double (two-phase) sampling with special reference to the selection with unequal probabilities in at least one of the phases; Double sampling for ratio and regression estimators of population mean, systematic sampling and its application to structured populations; Cluster sampling- equal clusters; Two-stage sampling with equal size of first stage units.

Unit IV (10 Lecture Hours)
Non-sampling error with special reference to non-response problems.

Recommended Books:
Course Title: Sampling Theory (LAB)
Course Code: STA.505
Total Hours: 30

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Experiments based on various sampling techniques and comparison in appropriate practical situations.
Course Title: Statistical Computing using FORTRAN
Course Code: STA.506
Total Hours: 38

Objectives:
The course is designed to equip the students with basic knowledge of computer and to develop programming skills and understanding of FORTRAN language.

Unit I
(9 Lecture Hours)
Introduction to Computers: Binary numbers, ASCII, floating point notation, Central Processing Unit, Microprocessor, Memory, Data storage devices, Input and Output devices, Computer based communication techniques.

Unit II
(9 Lecture Hours)
Introduction to Software: system software, Programming Languages, Program development: Defining the problem, Top-Down Design. Structured Design, developing an algorithm, flow chart, Testing and debugging the program.

Unit III
(10 Lecture Hours)
Programming Language - I: History of Fortran, Introduction to Fortran 95, Language elements, Character set, Tokens, Source Form, Concept of type, Literal constants of intrinsic type, names scalar variables of intrinsic type, derived data type, arrays of intrinsic type, character substrings, objects and sub objects, pointers.

Unit IV
(10 Lecture Hours)
Programming Language - II: Scalar numeric expressions and assignment, scalar relational operators, scalar logical expressions and assignments, scalar character expression and assignment. Structure constructors and scalar defined operators, scalar defined assignments, array expression, array assignments, pointers in expressions and assignments.

Recommended Books:
Course Title: Statistical Computing using Fortran (LAB)
Course Code: STA.507
Total Hours: 30

Control Constructs: The go to statement, the if statement and construct, the case and do constructs.
Input/output: Input/output statements, format definition, unit numbers, internal files, formatted input, formatted output, list directed I/O, carriage control, edit descriptors, unformatted I/O, data file and its processing.

Arrays Features and Specification Statements: zero-sized, arrays, assumed- shape arrays, automatic objects; allocate, deallocate and specify statements; elemental operations, where and for all statements and constructs, array elements, array objects and assignments, arrays of pointers, pointer as aliases, array constructors.

Specification Statements: Declaring entities of different shapes, initial values for variables, public and private attributes.

Program Units and Procedures: Main program, external subprogram, internal subprograms, modules, arguments of procedures, function subprogram, subroutine subprogram, explicit and implicit interfaces, procedure as arguments.

SPSS: Introduction, data files, data editor, data transfer, file handling, pivot tables, command syntax rules.
Course Title: Linear Algebra
Course Code: STA.508
Total Hours: 56

Objectives:
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 (14 Lecture Hours)
Vector Space: vector spaces, subspaces, direct sum of subspaces, linear dependence and independence, basis and dimensions, linear transformations, quotient spaces, algebra of linear transformations, linear functions, dual spaces, matrix representation of a linear transformation, rank and nullity of a linear transformation, invariant subspaces.

Unit II (15 Lecture Hours)
Characteristic polynomial and minimal polynomial of a linear transformation, eigenvalues and eigenvectors of a linear transformation, diagonalization and triangularization of a matrix, Cayley Hamilton Theorem, Matrix representation of Linear Transformation, Change of Basis, Canonical forms, Diagonal forms, triangular forms, Jordan Canonical Forms.

Unit III (14 Lecture Hours)
Bilinear forms, symmetric bilinear forms, Sylvester’s theorem, quadratic forms, Hermitian forms. Inner product spaces. Norms and Distances, Orthonormal basis, Orthogonality, Schwartz inequality, The Gram-Schmidt Orthogonalization process,

Unit IV (13 Lecture Hours)
The Adjoint of a Linear operator on an inner product space, Normal and self-Adjoint Operators, Unitary and Normal Operators, Bilinear and Quadratic forms, reduction and classification of quadratic forms.

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

The aim of this course is to make the students learn fundamental concepts of metric spaces, the Riemann-Stieltjes integral as a generalization of Riemann Integral, the calculus of several variables and basic theorem.

Unit I (15 Lecture Hours)
Elementary set theory: Real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, uniform convergence, Continuity, uniform continuity, differentiability, mean value theorem. 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 (14 Lecture Hours)
Convergent sequences (in Metric spaces), Cauchy sequences, subsequences, Complete metric space, Examples of complete metric space, Limits of functions (in Metric spaces), Continuous functions, continuity and compactness, Continuity and connectedness. Separable Metric spaces. Cantor’s intersection theorem, category of a set and Baire’s category theorem, Banach contraction principle.

Unit III (13 Lecture Hours)
Functions of several variables, linear transformation, Derivatives is an open subject, Chain rule, Partial derivatives, Jacobian, interchange of the order of differentiation, Derivation of higher order, inverse function theorem, implicit function theorem.

Unit IV (14 Lecture Hours)

Recommended Books:
Course Title: Basic Statistics
Course Code: STA.402
Total Hours: 32

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

Unit I  (8 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  (8 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)
Correlation and Regression analysis, rank correlation coefficients, curve fitting.

Recommended Books:
Semester II

Course Title: Computational Methods

Course Code: STA.403

Total Hours: 32

Objectives:
The course on Computational Methods has been framed to equip the students of M.Sc. Statistics with knowledge of programming in C, roots of equation, interpolation, curve fitting, numerical differentiation, numerical integration, solution of ordinary differential equations and probability.

Unit I

Programming with C: Introduction to the concept of object oriented programming, Advantages of C over conventional programming languages, Introduction to classes, objects, C programming syntax for Input/Output, Operators, Loops, Decisions, Simple and inline functions, Arrays, Strings, Pointers.

Unit II

Roots of Algebraic and Transcendental Equations: Element of computational techniques: roots of functions, Interpolation, Extrapolation, One point and two-point iterative methods such as bisection method and Newton Raphson methods.

Unit III

Integration and Differential: Integration by Trapezoidal and Simpson’s rule, Solution of first order differential equation using Runge-Kutta methods, Finite difference methods.

Data Interpretation and Error analysis: Dimensional analysis, Precision and accuracy, error analysis, Propagation and errors.

Unit IV

Least square fitting: Least square fitting, Linear and nonlinear curve fitting, Chi square test.
Random numbers: Introduction to random numbers, Monte Carlo method for random number generation.
Probability Theory: Elementary probability theory, Random variables, Binomial, poisson and normal distributions, Central limit theorem.

Recommended Books:
Course Title: Computational Methods (LAB)
Course Code: STA.404
Total Hours: 60

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Objectives:
The laboratory exercises have been so designed that the students learn to verify some of the mathematical concepts. They are trained in carrying out numerical problems using C language.

Student has to perform at least eight experiments out of the following list of experiments.

1. Data handling: find standard deviation, mean, variance, moments etc. of at least 25 entries.
2. Choose a set of 10 values and find the least squared fitted curve.
3. To find the roots of quadratic equations.
4. Perform numerical integration on 1-D function using Simpson rules.
5. Perform numerical integration on 1-D function using Trapezoid rule.
6. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.
7. To find the value of $\pi$ using Monte Carlo simulation.
8. To find the solution of differential equation using Runge-Kutta method.
9. To find the solution of differential equation using Euler’s method.
10. To find the value of $y$ for given value of $x$ using Newton’s interpolation method.

Recommended Books:
Course Title: Linear Models and Regression
Course Code: STA.510
Total Hours: 32

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 (8 Lecture Hours)
Linear Estimation: Gauss-Markov linear Models, Estimable functions, Error and Estimation Spaces, Best Linear Unbiased Estimator (BLUE), Least square estimator, Normal equations, Gauss-Markov theorem, generalized inverse of matrix and solution of Normal equations, variance and covariance of Least square estimators.

Unit II (8 Lecture Hours)
Test of Linear Hypothesis: One way and two way classifications. Fixed, random and mixed effect models (two way classifications only), variance components.

Unit III (8 Lecture Hours)
Linear Regression: 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 variance and detection of outlines. Remedies.

Unit IV (8 Lecture Hours)

Recommended Books:

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  
(12 Lecture Hours)  
**Estimation:** Introduction to the problem of estimation. Concepts of unbiasedness, sufficiency, consistency, efficiency, completeness.  

Unit II  
(12 Lecture Hours)  
**Tests of Hypotheses:** Concepts of critical regions, test functions, two kinds of errors, size function, power function, level of significance. MP and UMP tests in a class of size a tests.

Unit III  
(11 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  
(10 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:
Course Title: Estimation and Testing of Hypothesis (LAB)
Course Code: STA.512
Total Hours: 30
Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Mathematical Programming

Course Code: STA.513
Total Hours: 56

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Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of programming as well transportation problem.

Unit I (14 Lecture Hours)
Formulation of linear programming problem (LPP), graphical solution to LPP, properties of a solution to the (LPP) generating extreme point solutions. The simplex computational procedure, development of minimum feasible solution, a first feasible solution using slack variables, the artificial basis technique. Two phase method and Charnes M-method with artificial variables.


Unit II (14 Lecture Hours)

Unit III (14 Lecture Hours)
Replacement problem, replacement of items that Deteriorate, replacement of items that fails completely Individual Replacement policy: Mortality theorems, Group replacement policy, Recruitment and promotion problems.

Unit IV (14 Lecture Hours)
Inventory Management: Characteristics of inventory systems. Classification of items. Deterministic inventory systems with and without lead-time. All units and incremental discounts. Single period stochastic models. Job Sequencing Problems; Introduction and assumption, Processing of n jobs through two machines (Johnson’s Algorithm) Processing of n jobs through three machines and m machines, Processing two jobs through n machines (Graphical Method)

Recommended Books:
Course Title: Actuarial Statistics
Course Code: STA.514
Total Hours: 56

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

Unit III
(12 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:
Objective:
The course on Fundamentals of Computer Science and Programming in C, C++ has been framed to equip the students of M.Sc. Statistics with knowledge of programming in computer languages.

Unit I (11 Lecture Hours)
Basic Concepts: Historical development of C, Primary memory, Secondary storage devices, Input and Output devices, 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.

Unit II (12 Lecture Hours)

Unit III (11 Lecture Hours)

Unit IV (11 Lecture Hours)
Functions in C++: Passing arguments to and returning values from functions. Classes and objects: Specifying and using class and object, Arrays within a class, Arrays of objects, Object as a function arguments. Operator Overloading and Type Conversions: Overloading unary, binary operators. Inheritance: General concepts of Inheritance, Types of derivation-public, private, protected.

Recommended Books:
Course Title: Fundamental of Computer science and programming in C and C++ (LAB)
Course Code: STA.516

Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Demography and Vital Statistics
Course Code: STA.517
Total Lectures: 56

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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**
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**
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**

**Unit IV**

**Recommended Books:**

Course Title: Reliability Theory
Course Code: STA.518
Total Hours: 56

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 (14 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 (14 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 (14 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 (14 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:
Course Title: Statistical Simulation
Course Code: STA.519
Total Hours: 56

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
(14 Lecture Hours)

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

Unit III
(14 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:
Course Title: Basics of Inferential Statistics
Course Code: STA.405
Total Hours: 32

Objectives:
The course will help students from other streams 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
(8 Lecture Hours)

Unit II
(8 Lecture Hours)

Unit III
(8 Lecture Hours)
Parametric tests:-
One sample: $z$-test, student’s t-test, F and chi-square test. Two sample: $z$-test, student’s t-test, F, chi-square. Paired t-test and Analysis of Variance (ANOVA).

Unit IV
(8 Lecture Hours)
Non-Parametric tests:-

Recommended Books:
Semester III

Course Title: Research Methodology-II  
Course Code: STA.406  
Total Hours: 32  

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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  
Formulation of Research Problem and Hypothesis:  
**Research problem:** How to proceed? Necessary Conditions for formulation of research problem, Sources of research problem, Criteria of a Good Research Problem, formulation and stating the problem, Common errors.  
**Hypothesis:** The meaning, Importance, Type of sources, Characteristics of a usable hypothesis, The use of hypothesis in different types of research, Different forms of hypothesis in different types of research, Different forms of hypothesis, Difficulties in formulation of hypothesis, Testing the hypothesis.

Unit II  
**Literature Survey:** References, Abstraction of a research paper, Possible ways of getting oneself abreast of current literature.

Unit III  
**Documentation and Scientific Writing:** Result and conclusions; Preparation of manuscript for publication of research paper, Presenting a paper in scientific seminar, thesis writing. Structure and components of research report, Types of reports, Thesis, Research project reports, Pictures and graphs, Citation styles, Writing a review of paper, Bibliography.

Unit IV  
**Computer Applications:** Use of word processing, Spreadsheet and database software. Plotting of graphs, Internet and its applications: Email, WWW., Web browsing, acquiring technical skills, drawing inferences from data.

Recommended Books:  
Course Title: Numerical Analysis
Course Code: STA.601
Total Hours: 45

Objectives:
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 (11 Lecture Hours)
Eigen Value Problems: Power method and Jacobi method.
Polynomial Interpolation: Interpolating polynomial, Lagrange and Newton divided difference interpolation, Error in interpolation, Finite difference formulas, Hermite Interpolation.

Unit III (12 Lecture Hours)
Spline and Approximation: Cubic Spline, B-Spline, Least square method, Pàde approximation, Chebyshev Approximation.
Numerical Differentiation: Numerical differentiation with finite differences, Errors in numerical differentiation.
Numerical Integration: 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:
Course Title: Numerical Analysis (LAB)
Course Code: STA.602
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.
Course Title: Measure Theory  
Course Code: STA.603  
Total Hours: 56

Objectives:  
The objective of this course is to introduce student’s measure theory in an abstract setting after having studied Lebesgue measure on real line. The general $L^p$ spaces are also studied.

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

Unit II  
(14 Lecture Hours)  

Unit III  
(14 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 (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, Minkowski’s and Hölder’s inequalities, Riesz-Fischer theorem (statement only).

Recommended Books:
Course Title: Quality Control and Time series
Course Code: STA.604
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:
Course Title: Quality Control and Time Series (LAB)
Course Code: STA.605
Total Hours: 30

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Topics should include problems of Quality Control and Time Series using SPSS.
Objective:
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:

Course Title: Econometrics (LAB)
Course Code: STA.607
Total Hours: 30

Laboratory work should be related with the theory.
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 (14 Lecture Hours)

Unit II (16 Lecture Hours)
autocorrelation, power spectral density function.

Unit III (13 Lecture Hours)
Renewal theory: Renewal process, elementary renewal theorem and applications. Statement and uses of key renewal theorem, study of residual lifetime process.

Unit IV (13 Lecture Hours)

Recommended Books:
Course Title: Seminar
Course Code: STA.599
Total Hours: 32

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Semester IV

Course Title: Multivariate Analysis
Course Code: STA.609
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)
Wishart distribution and its properties. Distribution of sample generalized variance. Classification and discriminant procedure for discriminating between two multivariate normal populations, Sample discriminant function and tests associated with discriminant functions, probabilities of misclassification and their estimation.

Unit IV (11 Lecture Hours)

Recommended Books:

Course Title: Multivariate Analysis (LAB)
Course Code: STA.610
Total Hours: 30

Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Design and Analysis of Experiment
Course Code: STA.611
Total Hours: 45

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. $2^2$, $2^3$, $3^2$ and $3^3$ 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:
Course Title: Design and Analysis of Experiment (LAB)
Course Code: STA.612
Total Hours: 30
Laboratory experiments will be set in context with the materials covered in theory.
Course Title: Dissertation Research
Course Code: STA.600
Total Hours: 180

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Course Title: Advanced Numerical Methods
Course Code: STA.613
Total Hours: 56

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 (15 Lecture Hours)
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 (13 Lecture Hours)
Eigen-Values of Real Symmetric Matrix: Similarity transformations, Gerschgorin’s bound(s) on eigenvalues, 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 (13 Lecture Hours)
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 (15 Lecture Hours)

Recommended Books:
Course Title: Game Theory and Non-Linear Programming
Course Code: STA.614
Total Hours: 56

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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  
(14 Lecture Hours)

Unit II  
(14 Lecture Hours)

Unit III  
(14 Lecture Hours)

Unit IV  
(14 Lecture Hours)

Recommended Books:
Course Title: Non-Parametric Inference
Course Code: STA.608
Total Hours: 56

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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  
(14 Lecture Hours)
Estimable parametric functions, kernel, symmetric kernel, one sample U-Statistic, asymptotic distribution of U-Statistic, UMVUE property of U-Statistic. Empirical distribution function, confidence intervals based on order statistics for quantiles, tolerance regions.

Unit II  
(14 Lecture Hours)

Unit II I  
(14 Lecture Hours)

Unit IV  
(14 Lecture Hours)

Recommended Books:
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 (14 Lecture Hours)

Unit III (14 Lecture Hours)

Unit IV (13 Lecture Hours)

Recommended Books:

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

Unit I  (14 Lecture Hours)
The theory of Consumer Behaviour: Utility function, indifference curves and their properties, price and income elasticities, substitution and income effects.

Unit II  (14 Lecture Hours)

Unit III  (14 Lecture Hours)

Unit IV  (14 Lecture Hours)

Recommended Books:
Objectives:
This course is framed to equip the students of M.Sc. Statistics with concept of Queuing theory and Advanced Stochastic Process.

Unit I  
Queuing Theory: Steady state analysis of M/M/1, M/M/C queues. Method of stages for steady state solution of M/E_r/1 and E_r/M/1 queues. Simple design and control problems in queuing theory.

Unit II  
Non-Markovian Queuing Systems: Concept of imbedded Markov chain, Steady state solution, Mean number of arrivals, expected queue length and expected waiting time in equilibrium.

Unit III  
Inventory Models: Classification of inventory models, Deterministic inventory model (DIM), Basic Economic order Quantity (EOQ) models with no shortages, DIM with Shortages, EOQ with finite replenishment, EOQ with price break, single multi-item deterministic inventory models. Inventory problems with uncertain demand, Probabilistic (Stochastic) inventory models, Determination of Reserve Stock, Q-System/ P System, Uniform Demand & discrete units, instant demand & discrete units.

Unit IV  

Recommended Books: