# MAHARSHI DAYANAND UNIVERSITY, ROHTAK
# DEPARTMENT OF STATISTICS

**Scheme of the examination for M.Sc. (Statistics) w.e.f. 2016-17 (under CBCS)**

The duration of the course of instruction for M.Sc. (Statistics) degree shall be of two years (Four Semesters).There will be Five Theory Papers and Two Practicals in each semester. In addition of theory and practicals, students will have to submit a project work in M.Sc. second year. The detailed scheme of examination for M.Sc. (Statistics) is as follows:-

**Program Specific Outcomes**

## A. M.Sc. (Statistics)

PSO1: Acquired knowledge for applying Statistical Methodology and adapting modeling techniques to solve real life problems in both observational and designed studies.
PSO2: Acquired specialized skills for some specific areas of the subject Statistics at the advance level.
PSO3: Achieved practical experience for Data Analytics using statistical software including SPSS, MINI TAB and R.
PSO4: Acquired ability to develop Statistical Models and their fitting to the real life data.
PSO5: Acquired knowledge for Statistical interpretation of the analyzed data.
PSO6: Acquired knowledge for providing consultancy to insurance companies, banks, industries and software development.
PSO7: Enhanced research ability to carry out innovative research in the emergent fields of Statistics and Operations Research.
PSO8: Acquired sufficient knowledge for competing in Civil Services, Indian Statistical Services (ISS) , Forensic Science, Education and other allied services.

## M.Sc. First year

**Semester I**

| Course Code | Title of Paper | Theory Marks | Internal Assessment | Total Marks | Time Allowed | Credits |
|---|---|---|---|---|---|---|
| 16STA21C1 | Measure Theory & Linear Algebra | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA21C2 | Probability Theory | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA21C3 | Statistical Methods | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA21C4 | Computing Techniques | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA21C5 | Applied Statistics-I | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA21CL1 | Practical (Based on 16STA21C3) | 50 | — | 50 | 3 hrs | 02 |
| 16STA21CL2 | Practical (Based on 16STA21C4 & 16STA21C5) | 50 | — | 50 | 3 hrs | 02 |

**Semester II**

| Course Code | Title of Paper | Theory Marks | Internal Assessment | Total Marks | Time Allowed | Credits |
|---|---|---|---|---|---|---|
| 16STA22C1 | Real and Complex Analysis | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA22C2 | Inference-I | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA22C3 | Computer Programming | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA22C4 | Sampling Techniques | 80 | 20 | 100 | 3 hrs. | 04 |
| 16STA22C5 | Applied Statistics-II | 80 | 20 | 100 | 3 hrs. | 04 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 16STA22C6 | Practical (Based on 16STA22C2 & 16STA22C3) | 50 | — | 50 | 3 hrs | 02 |
| 16STA22C7 | Practical (Based on 16STA22C4 & 16STA22C5) | 50 | — | 50 | 3 hrs | 02 |
| **Foundation Elective** | | | | | | |
| To be chosen from the pool of foundation electives provided by the University. | | | | | | 02 |
| **Open Elective** | | | | | | |
| To be chosen from the pool of open electives provided by the University. | | | | | | 03 |

## M.Sc Second year

### Semester III

| Course Code | Title of Paper | Theory Marks | Internal Assessment | Total Marks | Time Allowed | Credits |
|---|---|---|---|---|---|---|
| 16STA23C1 | Multivariate Analysis | 80 | 20 | 100 | 03 hrs. | 04 |
| 16STA23C2 | Designs of Experiments | 80 | 20 | 100 | 03 hrs. | 04 |
| 16STA23C3 | Optimizations Techniques-I | 80 | 20 | 100 | 03 hrs. | 04 |
| 16STA23C4: Practical (Based on 16STA23C1) | | 50 | — | 50 | 03 hrs | 02 |
| 16STA23C5: Practical (Based on 16STA23C2) | | 50 | ---- | 50 | 03 hrs | 02 |
| Any two of the following: | | | | | | |
| 17STA23D1: Stochastic Processes & Queuing Theory | | 80 | 20 | 100 | 03hrs. | 04 |
| 17STA23D2: Agricultural Statistics | | 80 | 20 | 100 | 03hrs. | 04 |
| 17STA23D3: Official Statistics | | 80 | 20 | 100 | 03hrs. | 04 |
| **Open Elective** | | | | | | |
| To be chosen from the pool of open electives provided by the University. | | | | | | 03 |

### Semester IV

| Course Code | Title of Paper | Theory Marks | Internal Assessment | Total Marks | Time Allowed | Credits |
|---|---|---|---|---|---|---|
| 17STA24C1 | Econometrics | 80 | 20 | 100 | 03 hrs. | 04 |
| 17STA24C2 | Inference-II | 80 | 20 | 100 | 03 hrs. | 04 |
| 17STA24C3 | Optimization Techniques-II | 80 | 20 | 100 | 03 hrs. | 04 |
| 17STA24CL3: Practical (Based on 17STA24C3) | | 50 | — | 50 | 03 hrs | 02 |
| 17STA24CL4: Practical (Based on 17STA24C1 & 17STA24C2) | | 50 | ----- | 50 | 03 hrs | 02 |
| ST24C6: **Project Work** | | | | 100 | | 04 |
| **Any two of the following:** | | | | | | |
| 17STA24D1: Methods of Operations Research | | 80 | 20 | 100 | 03 hrs. | 04 |
| 17STA24D2: Actuarial Statistics | | 80 | 20 | 100 | 03 hrs. | 04 |
| 17STA24D3: Clinical Trials | | 80 | 20 | 100 | 03 hrs. | 04 |

## Project work:

The project work will start in the beginning of 'M.Sc.(Second year)' under the approved supervisors from amongst faculty members of the department. The last date for the submission of project work will be one month after the theory papers of 4th semester. The evaluation will be done by single external examiner after 4th semester on the basis of project work and viva voce. The Students securing F letter grade has to resubmit his project work.

*This Scheme will be applicable for 'M.Sc.( Statistics) First year' w.e.f. from 2016-17 and 'M.Sc. Second year' w.e.f. 2017-18.

## M. Sc. Semester-I
## 16STA21C1 (Measure Theory and Linear Algebra)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week.

**Paper Code: 16STA21C1**
**Paper: Measure Theory & Linear Algebra**
**Course Outcomes:**

CO1: Achieved knowledge to understand fundamentals of Probability Theory.
CO2: Acquired skill to apply Measure Theory in Inferential Statistics.
CO3: Ability to compute Eigen values and Eigen vectors.
CO4: Ability to understand Vector Spaces and its Properties.

**Section –I**

Field and Sigma Field. Measure and Probability Measure. Outer Measurability of Sets. Class of Measurable Sets. Construction of Outer Measure using Sequential Concerning Classes. Lebesgue Measure. Construction of Non-Measurable Sets.

**Section –II**

Measurable Function as a Random Variable. Simple Functions. Sequences and Algebra of Measurable Functions. Approximation Theorem of Measurable Functions. Concepts of Almost Everywhere (a.e) and Almost Uniform Convergence. Egoroffs Theorem. Lusin Theorem.

**Section –III**

Convergence in Measure. Fundamental in Measure. F.Riesz Theorem for Convergence in Measure. Integral of a Measurable Function w.r.t a Measure. Bounded Convergence Theorem. Fatou's Lemma, Monotone Convergence Theorem. General Lebesgue Integral and Lebesgue Dominated Convergence Theorem.

**Section –IV**

Linear and Orthogonal Transformation of a Matrix. Eigen Values and Eigen Vectors of a Liner Transformation. Quadratic Forms and Their Reduction to Canonical Form. Signature of a Matrix. Positive Definite Matrix.

**Books Suggested:-**


1. Burril, C.W. : Measure Theory and Probability
2. Halmos, P.R. : Measure Theory
3. Royden, H.L : Real Analysis
4. Munroe, M.E. : Introduction to Measure and Integration
5. Kingman .J.F.C. : Introduction to Measure and Probability

And Taylor,S.J.
6. Data, K.B. : Matrix and Liner Algebra
7. Hadley, G. : Liner Algebra
8. Sushma, V. : Liner Algebra

**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA21C2 (Probability Theory)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week.

**Paper Code: 16STA21C2**
**Paper: Probability Theory**
**Course Outcomes:**
CO1: Provided a base to understand fundamentals of Statistics.
CO2: Achieved knowledge to understand Probability Distributions.
CO3: Updated skill to study random processes as Probabilistic Models.
CO4: Ability to generate random numbers using probability distributions.
CO5: Enable to calculate probability of ultimate extinction of a population.

**Section - I**

Random Experiment, Sample Space, Events – Simple, Composite, Mutually Exclusive and Exhaustive Events, Various Definitions of Probability, Properties of probability function, Addition Theorem, Boole's and Bonferroni's Inequalities, Conditional Probability, Multiplication Theorem, Baye's Theorem, Independence of Events.

**Section-II**

Random Variables and Distribution Functions , Probability Mass function, Probability density Function, Two Dimensional Random Variables- Joint , Marginal and Conditional Distributions, Independence of Random Variables.
Moments of Random Variables – Expectation, Variance, Covariance, Conditional and Marginal Expectation.

**Section- III**

Probability and Moment Generating Function and their Properties, Characteristic Function and its properties, Continuity Theorem Inversion Theorem , Uniqueness Theorem of Characteristic Function, Moment Inequalities of Hölder, Minkowski, Jensen's , Cauchy- Schwartz and Lyapunov's

**Section -IV**

Modes of Convergence -Convergence in Probability, almost surely, in the $r^{th}$ mean and in distribution, their relationship. Probability Inequalities of Chebychev and Markov , Weak Law of large numbers- Chebychev's, Bernoulli's and Khintchine's Weak Law of Large Numbers, necessary and sufficient conditions for the WLLN,
Borel Cantelli Lemma, Kolmogorov inequality, Strong law of large numbers-Kolmogorov's theorem.
Central Limit Theorem, Lindeberg - Levy and Demoivre- Laplace forms of CLT.

**Books Recommended**

1. Meyer P. L. - Introductory Probability and Statistical Applications (Addison Wesley)
2. Goon, A.M., Gupta, M.K. and Dasgupta. B. (1985): An Outline of Statistical Theory, Vol. I (World Press)
3. Freund J.E. – Mathematical Statistics (Prentice Hall )
4. Mukhopadhyaya P. (1996) Mathematical Statistics (New Central Book Agency)
5. Rohatgi, V. K. and Saleh, A.K. Md. E. (1603): An Introduction to Probability and Statistics, Second Edn., John Wiley.
6. Feller, W. (1968): An Introduction to Probability Theory and its Applications,3rd Edition, Vol. 1, John Wiley & Sons.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA21C3 (Statistical Methods)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week.

**Paper Code: 16STA21C3**
**Paper: Statistical Methods**
**Course Outcomes:**

CO1: Achieved knowledge to understand presentation and interpretation of the data.
CO2: Able to understand measures of central tendencies and dispersions.
CO3: Expertise in applying Probability Distributions for the solution of real life problems.
CO4: Ability to perform to test hypothesis for large samples and small samples.

**Section-I**

Raw and Central Moments, Skewness and Kurtosis. Analysis and Consistency of Categorical Data, Independence and Association of Attributes. Principle of Least Squares, Fitting of Curves, Correlation and Regression,

**Section - II**

Correlation Ratio. Interclass Correlation. Partial and Multiple Correlations. Probability Discrete Distributions: Binomial, Poisson, Multinomial, Hyper Geometric, Geometric. Negative Binomial, Uniform

**Section - III**

Probability Continuous Distributions: Rectangular, Exponential, Normal, Beta, Gamma, Weigbul, Laplace, Cauchy, Lognormal Distributions, Bivariate Normal. Sampling Distribution of Mean And Variance.

**Section - IV**

Large Sample Theory, Chi-Square, Student's and Snedecor's F, Fisher's-Z Distribution and Their Applications. Elementary Ideas Of Non-Central Distributions.

**Books suggested:-**

1. Hogg, R. V., Mckean, J. and Craig, A. T. Introduction to Mathematical Statistics, Prentice Hall.

2. Mood, A.M., Graybill, F.A. & Bose, D.C. Introduction to the Theory of Statistics, Mc Graw- Hill.
3. Goon A.M., Gupta M.K & Dasgupta B Outlines of Statistics, Volume-I, The World Press
4. Mukhopadhayaya. P Mathematical Statistics, Books & Allied.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA21C4 (Computing Techniques)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week.

**Paper Code: 16STA21C4**
**Paper: Computing Techniques**
**Course Outcomes:**

CO1: Ability to solve the ordinary differential equation and partial differential equation by laplace transform and inverse laplace transformation.
CO2: Ability to solve ordinary differential equation by using Iterative Methods.
CO3: Ability to find eigen values and eigen vectors of a matrix by Jacobi and Power method.
CO4: Acquired with the basic of C Language.
CO5: Fully equipped with the techniques of developing his own programs for Mathematical as well as Statistical Methods.

**Section -1**

Evaluation of Eigen Values and Eigen Vectors of Matrices by Power and Jacobi Method. Solution of Ordinary Differential Equations: Taylor's Method, Euler's, Modified Euler's, Picard and Runga Kutta Method, Predictor – Corrector Methods, Admas – Moulton Method, Milne's Method . Boundary Value Problems

**Section –2**

Laplace and Inverse Laplace Transforms: Definitions and Basic Properties. Convolution Theorem. Applications of Laplace Transforms to the Solution of Linear Ordinary Differential Equations, Partial Differential Equations and Integral Equations.

**Section- 3**

Basic Concepts of Object Oriented Programming Problems (OOP), Advantages and Applications of OOP, History and Features of C Language, Components of C Language. Data Type: Basic Data Types, Enumerated Data Types, Derived Data Types. Variable Declaration: Local, Global, Parametric Variables, Assignment of Variables. Numeric Character, Real and String Constants. Operators, Type Modifiers and Expressions. Basic Input/Out Put, Control Statements, Decision Making Statements

**Section- 4**

Dimensional Arrays: One, Two and Multi. Storage Classes, Functions, Classification of Functions Definition and Declaration, Assessing A Function, Return Statement, Parameter Passing In Functions Recursion In Functions, Pointers; Pointer and Array, Pointer and Functions: Pointers to Pointers, Pointers

To Functions, Function Returning Pointers, Functions With Variable Number of Arguments Preprocessor, Structure and Union.

**Books Suggested:**


Sastry, S.S. : Introduction to Methods of Numerical Analysis, PHI learning Pvt.Ltd.

Nielson, K.L. : Methods of Numerical Analysis, Macmillan, New York.

Willaims, J. : Laplace Transforms, George Allen & Unwin Ltd.

Balagurusamy, E. : Programming C, Tata MaGraw Hill.

Kernighan, Brain W. and Ritchie, Dennis M. (1989) : The C Programming Language, Prentice Hall

Knuth, Donald E. (2002) : The Art of Computer Programming, Addison-Weley.

Salaria, R.S. : A Beginner's Guide to Computer Programming with C, Khanna Book Publishi Co(P)


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA21C5 (Applied Statistics-I)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week

**Paper Code: 16STA21C5**
**Paper: Applied Statistics**
**Learning Outcomes:**

CO1: Acquired knowledge of Index Number, Demand Analysis and their interpretation.
CO2: Acquired knowledge of population, projection and estimation.
CO3: Be familiar with the sources of vital statistics data and how birth rate, mortality rate and reproduction rate are calculated and interpreted.
CO4: Familiarization with official statistical system of India.

**Section-I**

Methods of Obtaining Demographic Data, Measurement of Population at Given Time, Rates and Ratios, Measurement of Mortality; Crude Death Rate, Specific Death Rate, Standardized Death Rate, Infant Mortality Rate. Construction of A Complete Life Table and Its Uses. Abridged Life Tables; Kings Method. Reed And Merrill's Method. Greville's Method, Chiang's Method.

**Section-II**

Measurement of Fertility: Crude Birthrate, General Fertility Rate, Age Specific Fertility Rate, Total Fertility Rate, Relation Between TFR And CBR, Gross Reproduction Rate and Net Reproduction Rate, Replacement Index. Standardized Fertility Rate. Structure of Population, Stable and Quasi Stable Populations, Intrinsic Rate Of Growth, Population Projection By Component Method, Reduction of Mortality Curves; Gompertz's and Makeham Formula, Logistic Curve and Its Use In Population Projection.

**Section-III**

Demand Analysis– Laws of Demand and Supply, Price and Supply Elasticity of Demand. Partial and Cross Elasticity of Demand. Income Elasticity of Demand. Utility Function Methods of Determining Demand and Supply Curves From Family Budget and Time Series Date, Leontief's Method, Pigou's Method Engel Curve And Its Different Forms,. Pareto's Law of Income Distribution. Curves of Concentration.

**Section-IV**

Index Numbers and Their Construction, Uses of Index Numbers. Price, Quantity and Value Relatives, Link and Chain Relatives, Laspeyer's, Paashce's, Marshall –Edge Worth and Fisher's Index Numbers, Chain Base Index Numbers, Tests For Index Numbers. Base Shifting, Splicing and Deflating of Index Numbers. Cost of Living Index Numbers.

Official Statistics: Statistics System In India CSO and NSSO And Its Function, Present Structure of The Indian Statistical System, Function of A Statistical System, Agricultural Statistics, Trade Statistics, Labor And Employment Statistics, Transport and Communication Statistics, Financial and Banking Statistics.

**Books Recommended**:-


1. Biswas, S; : Stochastic Processes in Demography and Applications
2. Goon A.M., Gupta M.K. & Das Gupta, B (1601) : Fundamentals of Statistics Volume-11
3 Mukhopadhyay. P. (1999) : Fundamental of Statistics Volume-11
4. Croxton, F.E & Cowdon, D.J. : Applied General Statistics, Prentice Hall


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

**16STA21CL1-**Practicals (Based on **16STA21C3)** and will be of duration 3 hours.

**Paper Code: 16STA21CL1**
**Paper: Practical's (Statistical Methods-16STA21C3)**
**Course Outcomes:**

CO1: Able to understand methods for presentation of the data.
CO2: Updated knowledge to solve simple task to using statistical software's.
CO3: Acquired knowledge to carry out correlation and regression analysis.
CO4: Enhanced knowledge to understand the situations where measures of central tendencies and dispersions are to be used.
CO5: Able to understand statistical hypothesis testing.

**16STA21CL2-**Practicals (Based on **16STA21C4 & 16STA21C5)** and will be of duration 3 hours.

**Paper Code: 16STA21CL2**
**Paper: Practical's (Computing Techniques & Applied Statistics I - 16STA21C4 & 16STA21C5)**
**Course Outcomes:**

CO1: Learn basic scientific computing for solving ordinary differential equation.
CO2: Ability to make and run error free C programs related to mathematical and statistical problems.
CO3: Ability to analyze the demographic data, economic data etc.
CO4: Ability to make complete and abridged life tables.

The practical question paper will consist of five questions and the students will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiners. Distribution of Marks will be as follows: -

| | | |
|---|---|---|
| Marks for Question Paper | : | 36 |
| Marks for Practical Record book | : | 06 |
| Marks for Viva-Voice | : | 08 |
| Total | : | 50 |

# M. Sc. Semester-II
# 16STA22C1 (Real and Complex Analysis)

Maximum Marks: 80
Internal Assessment Marks: 20
Time: 3 Hours
Teaching Hours: 4 Hours per week

**Paper Code: 16STA22C1**
**Paper: Real and Complex Analysis**
**Course Outcomes:**

CO1: Updated knowledge about convergence properties of complex and real functions.
CO2: Acquired ability to learn differentiation techniques for complex functions.
CO3: Able to understand applications of complex analysis in Bayesian inference.
CO4: Able to understand the analytic properties of the complex functions.

**Section –I**

Topology of Real Numbers: Open Set, Closed Set, Limit Point of a Set, Bounds of a Set. Convergence and Divergence of Sequences. Cauchy's Theorem on Limits, Sequence and Series of Functions and Their Convergence Properties.

**Section –II**

Functions of a Complex Variable and Their Analytic Properties. Cauchy's Riemann Equations. Power series and its Radius of Convergence. Elementary idea of Mobius Transformation, Cross Ratio, Invariant Point and Critical point

**Section –III**

Regular and Rectifiable Arcs. Contour. Domains: Connected, Simply Connected and Multiply Connected. Complex Line Integrals. Cauchy's theorem, Cauchy's Integral Formulae and Inequality. Morera's Theorem. Liouvelle's Theorem. Taylor and Laurent Series

**Section -IV**

Singularities and Their Classification. Poles and Zeros of a Meromorphic Function, Argument Principle. Rouches Theorem. Fundamental Theorem of Algebra. Residues. Cauchy's Residue Theorem. Application of Cauchy's Residue Theorem for Evaluation of Integrals of Real valued Functions.

**Books Suggested:-**


1. Narayan, Shanti : A Course of Mathematical Analysis
2. Malik,S.C. & Arora,Savita : Mathematical Analysis
3. Copson, E.T. : Introduction to the Theory of Functions of a Complex Variable
4. Pati,T : Functions of a Complex Variable.
5. Sharma, J.N. and Swarup, Shanti : Function of a Complex Variable
6. Goyal and Gupta : Function of a complex Variable (Pargati Parkashan Meerut)
7. Malik, S.C. : Real and Complex Analysis (Jeevan Sons Publication, New Delhi)


**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

# 16STA22C2 (Inference- I)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week.

**Paper Code: 16STA22C2**
**Paper: Inference I**
**Course Outcomes:**
CO1: Ability to estimate unknown parameters of a given probability distribution.
CO2: Ability to test simple and composite hypothesis.
CO3: Ability to apply MP Test, UMP Test, UUMP Test for finding out critical region.
CO4: Ability to recognize methods of obtaining confidence interval.

**Section -I**
Problem of Point Estimation: Properties of Estimators: Un-biasedness Consistency, Sufficiency, Neymann Factorization Theorem, Complete Sufficient Statistics, Efficiency, Minimum – Variance Unbiased (MVU) Estimators, Exponential Family of Distributions and its Properties, Cramer- Rao Inequality, Minimum Variance Bound (MVB) Estimators, Bhattacharya's Bounds.

**Section - II**
Rao-Blackwell Theorem, Lehman Schefe's Theorem and its Applications in Finding Uniformly Minimum Variance Unbiased Estimators Methods of Estimation: Maximum Likelihood, Moments, Least Square, Minimum Chi- Square and Modified Minimum Chi- Square and Their Properties.

**Section- III**
Neymann Theory of Testing of Hypotheses, Simple and Composite Hypotheses, Null and Alternative Hypotheses, Two Types of Errors, Critical Reason, Level of Significance, Power of The Test, Unbiased Tests, Critical Reason, N-P Lemma, Construction of Most Powerful Test, Uniformly Most Powerful Test, Uniformly Most Powerful Unbiasedness Tests.

**Section- IV**
Likelihood Ratio Test: Derivation and its Properties, Asymptotic Distribution of L.R. Test. Interval Estimation: Method of Obtaining Confidence Intervals Based on Small and Large Samples. Unbiased and Shortest Expected Length Confidence Interval.

**BOOKS SUGGESTED**


1. Goon, A.M., M.K.Gupta, & B. Das Gupta : Outline of Statistics Vol-II
2. Kendall, M.G. and Straut, A. : Advanced Theory of Statistics
3. Rohtagi, V.K. : Theory of Mathematical Statistical
4. Rao, C .R. : Linear Statistical Inference and its Applications


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

# 16STA22C3 (Computer Programming)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 16STA22C3**
**Paper: Computer Programming**
**Course Outcomes:**

CO1: Understand the basic structure of Fortran-77 and ability to write program to solve the scientific problems.
CO2: Understand the basic structure of C++ and ability to write simple programs in C++.
CO3: Ability to create source file.
CO4: Understand how to apply the measure object-oriented concept to implement object oriented program in C++.

**Section-1**

Introduction to Fortran 77, Data Type, Operators and Expressions, Assignment Statement, Arithmetic and Logical Operation, List Directed and Format-Directed Input/Output Statement. Control Statements, Arrays, Dimension Statement, User Defined Function, Function Subprograms, Subroutine Subprograms, Builtin-Functions.

**Section-2**

Introduction to C++. Structure of a C++ Program. Creating the Source Files. Compiling and Linking, C++ Programming Basics: Input/Output, Data Types, Operators, Expressions, Control Structures, Library Functions, Functions In C++ : Passing Arguments to and Returning Values From Functions, Inline Functions, Default Arguments, Function Overloading.

**Section-3**

Classes and Objects : Specifying and Using Class and Object, Arrays Within A Class, Arrays of Objects, Object As A Function Arguments, Friendly Functions, Pointers to Members, Constructors and Destructors. Operator Overloading and Type Conversions. Inheritance: Derived Class and Their Constructs, Overriding Member Functions.

**Section – 4**

Pointers to Objects, This Pointer, Pointers to Derived Classes, Virtual Functions, Streams, Stream Classes, Unformatted Input/Output Operations, Formatted Console Input/Output Operations, Managing Output with Manipulators, Opening and Closing A File. File Pointers and Their Manipulations, Error Handling During File Operations.

**Books Suggested:**


Ram Kumar : Introduction to Fortran-77 Tata McGraw Hill
Rajaraman, V : Computer Programming in Fortran 77, Prentice-Hall India
William, E. M. & Cwiakala, M. : Programming with Fortran-77, Tata McGraw Hill
I.S. Robert Lafore : Object Oriented Programming using C++, Sams Publications :
E. Balagurusamy : Object Oriented Programming with C++, Tata McGraw Hill
Byron S. Gottfried : Object Oriented Programming using C++, Tata McGraw Hill

**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA22C4 (Sampling Techniques)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 16STA22C4**
**Paper: Sampling Techniques**
**Course Outcomes:**

CO1: Ability to understand techniques for conducting Sample Surveys.
CO2: Able to identify and define the population to be studied, control of non-sampling errors and sampling design of the Indian National Sample Survey.
CO3: Able to describe common methods of sampling, the estimation of ratios and differences, the use of auxiliary information at the estimation stage.
CO4: Understand the different sampling schemes (stratified sampling, cluster sampling, multi-stage and multi-phase sampling).

**Section-I**

Sample Versus Complete Enumeration. Designing of Sample Surveys, Sources of Errors In Sample Surveys, Types of Non-Response Errors Probability and Purposive Sampling, Simple Random Sampling with or without Replacement for The Estimation of Mean Total. Proportion and Ratio, Determination of Sample Size for Specified Precision Stratified Sampling: Proportional and Optimum Allocation. Estimation of Gain Due To Stratification. Construction of Strata and Determination of Number of Strata.

**Section -II**

Ratio Estimates, Approximate Variance, Comparison with Mean Per Unit Estimate. Optimum Conditions, Bias of The Ratio Type Estimate, Unbiased Ratio Type Estimate Due to Hartley and Ross, Ratio Estimate in Stratified Sampling. Regression Estimators (Pre –Assigned and Estimated from the Sampling Comparison with the Ratio and Mean per Unit Estimates in Stratified Sampling.

**Section -III**

Double Sampling (Two Phase Sampling) for Ratio and Regression Methods of Estimation. Systematic Sampling, Comparison with Stratified and Simple Random Sampling, Single Stage Cluster Sampling, and Variance in terms of Inter Cluster Correlation. Jessen'scost Function and Determination of Optimum Sampling Unit.

**Section –IV**

Sampling with Varying Probability, Sampling with Probability Proportional to Size Lahiri Method of Selection Unequal Probability Sampling with Replacement and without Replacement Horvitz Thompson Estimator, its Variance and Unbiased Estimate of this Variance. Two Stage Sampling, Estimate of Population Mean and its Variance, Optimum Allocation for Fixed Cost.

**BOOKS SUGGESTED: -**


1 .Chochran,W.G. : Sampling Techniques 2.
DarogaSingh&F.S.Chaudhary : Theory & Analysis of Sample Survey designs
3. Hasen,Hurwitz and Madow : Sample Survey Methods & Sampling
4.Mukhopadhyay,Primal : Theory and Methods of Survey Sampling
5.Goon A.M.Gupta & M.K.Dass Gupta : Outline of Statistics Vol-11

6.P.V.Sukhatme & B.V.Sukhatme : Theory and application of Sample Surveys

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 16STA22C5 (Applied Statistics-II)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week.

**Paper Code: 16STA22C5**
**Paper: Applied Statistics II**
**Course Outcomes:**

CO1: Achieved knowledge about the use of time series in forecasting and economic analysis.
CO2: Able to understand of manufacturing process and specification limits.
CO3: Acquired skill to derive the concepts of auto-covariance, autocorrelation, box Jenkin's models and estimation of parameters in ARIMA models.
CO4: Able to understand the methods to make a process stable in industries and other areas.

**Section-I**

Analysis of Time Series, Components of Time Series, Trend Measurement by Mathematical Curves: Polynomial, Growth Curves. Moving Average Method, Spencer's Formulae, Effect of Elimination of Trend on Other Components of Time Series. Variate Difference Method and its Use for Estimation of Variance of the Random Component. Measurement of Seasonal Fluctuations, Measurement of Cyclical Component; Periodogram Analysis.

**Section-II**

Concept of Stationary Time Series, Strong and Weak Stationary: Auto Covariance and Auto Correlation. Correlogeam of Auto Regressive Scheme. Moving Average Scheme and A Harmonic Series. Box Jenkin's Models, Estimation of Parameters in ARIMA Models, Forecasting: Exponential and Adaptive Smoothing Models.

**Section-III**

Statistical Quality Control and Its Purposes, 3 Sigma Control Limit, Shewart Control Chart. Control Charts For Variables and Attributes, Natural Tolerance Limits and Specification Limits: Modified Control Limits. Sampling Inspection Plan, Producer's and Consumer's Risk OC and ASN Function, AQL. LTPD and ATI.

**Section-IV**

The Single, Double and Sequential Sampling Plans and Their Curves Viz AOQ, OC, ASN and ATI Carvers. The Choice Of Sampling Plans by Attributes and by Variables. Acceptance Plan by Variables, Single and Sequential Sampling Plans, Acceptance Sampling by Variables (Known and Unknown Sigma Case)

**BOOKS SUGGESTED: -**


1. M.G.Kindall : Time series
2. Goon, A.M., Gupta, M.K and Das Gupta B : Fundamentals of Statistics Vol.-2
3. Montgomery, D.E. : Introduction to Statistical Quality Control.
4. Croxton and Cowden : Applied General Statistics
5. Kendall and Stuart : Advances in Statistics Vol-3

6. Grant E. L : Statistics Quality Control, Wiley Easten

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

**16STA22C6:**Practical (Based on papers **16STA22C2** & **16STA22C3**) and will be of duration 3 hours.

**Paper Code: 16STA22C6**
**Paper: Practical's (Inference I & Computer Programming) - 16STA22C2 & 16STA22C3**
**Course Outcomes:**
CO1: To understand how to make the an error free C++ program using inheritance, abstraction, encapsulation and polymorphism.
CO2: Ability to find out population parameters on the basis of sample.
CO3: Ability to find out confidence interval and best critical region for practical problems.

**16STA22C7:**Practical (Based on papers **16STA22C4** & **16STA22C5**) and will be of duration 3 hours.
**Paper Code: 16STA22C7**
**Paper: Practical's (Sampling Techniques & Applied Statistics II) - 16STA22C4 & 16STA22C5**
**Course Outcomes:**
CO1: To understand how to make the error free C++ program using inheritance, abstraction, encapsulation and polymorphism.
CO2: Ability to find out population parameters on the basis of sample.
CO3: Ability to find out confidence interval and best critical region for practical problems.

The practical question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.
Distribution of marks will be as follows: -

| | | |
|---|---|---|
| Marks for Question Paper | : | 36 |
| Marks for Practical Record book | : | 06 |
| Marks for Viva-Voice | : | 08 |
| Total | : | 50 |

## Semester III
## 17STA23C1 (Multivariate Analysis)

Max Marks- 80
Internal Assessment: 20
Time: 03 Hours
Teaching Hours: 04 hrs per week.

**Paper Code: 17STA23C1**
**Paper: Multivariate Analysis**
**Course Outcomes:**
CO1: Able to handle multivariate data with Normal distribution.
CO2: Acquired knowledge to analyze multivariate data with given mean vector.
CO3: Able to understand testing hypotheses for mean correlation and regression coefficients.
CO4: Ability to find major factors and the variability using multivariate techniques of principal component, factor analysis, discriminant function and clustering analysis.

**Section-I**

Multivariate normal distribution, Marginal and Conditional Distributions Characteristic Function, Distribution of Linear Combinations of Normal Vector, Random sampling from a multivariate normal distribution, Maximum likelihood estimators of Mean vector and Covariance Matrix. Distribution of sample mean vector, Distribution of Quadratic forms.

**Section –II**

Wishart matrix - its distribution (without proof) and properties. Distribution of sample generalized variance, Null Distributions and uses of Simple, Partial and Multiple Correlation Coefficients. Hotelling's $T^2$ statistic –Derivation and its Null distribution Uses of $T^2$ statistic, Beheran - Fisher's Problem.

**Section –III**

Multivariate Linear Regression Model. Estimation of parameters and their properties. Distribution of The Matrix of Sample Regression Coefficients, Test of Linear Hypothesis About Regression Coefficients, Multivariate Analysis of Variance [MANOVA] of One Way Classified Data. Wilk's Lambda Criterion, Likelihood Ratio Test Criteria for Testing Independence of Sets of Variables.

**Section -IV**

Likelihood Ratio Criteria for Testing Equality of Covariance Matrices and Identity of Several Multivariate Normal Populations, Fisher's Discriminant Function, Mahalanobis' Distance, Principal Components, its Uses and Importance, Canonical Variables and Canonical Correlations.

**Books Recommended**


1. anderson, T.W.: An Introduction to Multivariate Statistical Analysis, John Wiley
2. Rao, C. R.: Linear Statistical Inference and its Applications, John Wiley
3. Johnson, R. A. and Wichern, D. W. (2001) : Applied Multivariate Statistical Analysis, Prentice Hall of India
4. Rencher, A. C. (2002) : Methods of Multivariate Analysis, 2nd Ed., John Wiley & Sons.


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C &D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 17STA23C2 (Designs of Experiments)

Max Marks: 80
Internal Assessment: 20
Time: 3 hrs.
Teaching hrs per week: 04 hrs per week.

**Paper Code: 17STA23C2**
**Paper: Designs of Experiments**
**Course Outcomes:**

CO1: Able to learn the issues and principles for the experimentation process. Listing guidelines for designing experiments.
CO2: Able to layout and analyze the experiment for one directional variation and two directional variation.
CO3: Ability to estimate the missing observations and then analyze the data.
CO4: Acquired knowledge to layout the experiments for split plot and strip plot designs and to carry out their analyses.
CO5: Understand how to allocate treatments in factorial experiments of two factors with two levels. Analyze it using Yate's technique.

**Section- I**

Linear Models: Standard Gauss Markov Models, Estimability of Parameters, Best Linear Unbiased Estimator (BLUE), Method of Least Squares, Gauss-Markov Theorem, Variance- Covariance Matrix of Blues.

**Section-II**

Analysis of Variance for One- Way, Two -Way With One/M Observations Per Cell for Fixed, Mixed and Random Effects Models, Tukey's Test for Non- Additively. General Theory of Analysis of Experimental Designs; Completely Randomized Design, Randomized Block Design and Latin Square Designs, Missing Plot Techniques in RBD and LSD,

**Section- III**

Analysis of Covariance for CRD and RBD.Split Plot and Strip Plot Designs. General Factorial Experiments: Definition, Estimation of Factor's Effect. Analysis of The Factorial Experiments Using CRD and RBD.

**Section-IV**

Incomplete Block Designs; Balanced, Connectedness, Orthogonality and Resolvability. Balanced Incomplete Block Design With and Without Recovery of Inter Block Information, Youden Squares.

**BOOKS SUGGESTED**


1. Goon A.M., Gupta ,M.K.and Dass Gupta,B. :Outline of Statistics Vol.-II
2. Dass, M.N. and Giri, N.C :Design and analysis of Experiments
3. Aloke Dey :Theory of Block Designs
4. Raghavrao, D. : Construction & Combinatorial Problems in Design of Experiments (John Wiley, New York)


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 17STA23C3 (Optimization Techniques-I)

Maximum Marks: 80
Internal Assessment Marks: 20
Time: 3 Hours
Teaching Hours: 4 Hours per week

**Paper Code: 17STA23C3**
**Paper: Optimization Techniques- I**
**Course Outcomes:**

CO1: Acquainted with the formulation of the real life problems as Linear Programming Problems (LPP).
CO2: Able to use techniques for obtaining optimal solution of the problems of LPPs.
CO3: Acquired knowledge for achieving optimal solutions of the Transportation and Assignment Problems.
CO4: Enhanced computing power for determining alternate solutions of the LPP.
CO5: Able to understand the importance of extreme points in obtaining the optimal solution.

**Section –I**

Convex Sets and Functions. Linear Programming Problems: Formulation, Examples and Forms. Properties of a Solution to the LPP. Development of Optimum Feasible Solution. Solution of LPP by Graphical and Simplex Methods. Solution of Simultaneous Equations by Simplex Method.

**Section –II**

Artificial Variable Techniques: Big-M-Method and Two Phase Simplex Method. Degeneracy in LPP and its Resolution. The Revised Simplex Method. Bounded Variable Technique.

Duality in LPP: Symmetric and Un-Symmetric Dual Problems. Fundamental Duality Theorem. Complementary Slackness Theorem. Dual Simplex Method. Economic Interpretation of Duality.

**Section –III**

Post- Optimization Problems: Sensitivity Analysis and Parametric Programming. Integer Programming Problems(IPP). Gomory's Algorithem for Pure Integer Linear Programs. Solution of IPP by Branch and Bound Method. Applications of Integer Programming.

**Section –IV**

Transportation Problems: Mathematical Formulation and Fundamental Properties. Initial Basic Feasible Solution of Transportation Problems by North West Corner Rule, Lowest Cost Entry Method and Vogel's Approximation Method. Optimal Solution of Transportation Problems.

Assignment Problems: Mathematical Formulation and Solution by Hungarian Assignment Method. Reduction Theorem. Sensitivity in Assignment Problems.

**Books Suggested:-**


| | | | |
|---|---|---|---|
| 1. | Gass, S.I. | : | Linear Programming (Methods and Applications) |
| 2. | Kambo, N.S | : | Mathematical Programming Techniques |
| 3. | Sinha, S.M. | : | Mathematical Programming (Theory and Methods) |
| 4. | Bazaraa, M.S Jarnis, J and Sherali,H.D. | : | Linear Programming and Network Flows |
| 5. | Hadely,G. | : | Linear Programming |


**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## Optional Papers:

## (a) (Stochastic Processes and Queuing Theory) 17STA23D1

Maximum Marks: 80
Internal Assessment Marks: 20
Time: 3 Hours
Teaching Hours: 4 Hours per week

**Paper Code: 17STA23D1**
**Paper: Stochastic Processes and Queuing Theory**
**Course Outcomes:**

CO1: Demonstrate ability to the basic concepts of theory of Markov Chain.
CO2: Obtained understanding for the solution of stochastic differential equations.
CO3: Able to understand the applications of the Probability Theory.
CO4: Able to understand the use of probability generating functions.
CO5: Acquired ability to formulate mathematical models for the steady state solutions of queuing systems.

**Section-I**
Stochastic Processes: Definition, Classification and Examples. Branching Process: Probability of Extinction and Distribution of Total Progeny. Random Walk: First Passage Time, Gambler's Ruin Problem and Duration of the Game.

**Section-II**
Markov-Chains: Classification of States and Chain, Higher Transition Probabilities, Stability of Markov Systems and Limiting Behaviour. Poisson Process: Classifications, Related Distributions and Generalization. Birth and Death Processes: Yule-Furry Process and Generalization. Linear Birth-Death Process.

**Section-III**
Queuing Process: Description of Queuing Problems, Notations, Measures of Effectiveness and Characteristics. Queues with Parallel Channels of Truncation. Queuing systems: M/M/1, M/M/C, M/M/$\infty$, M/M/1/R, and M/M/C/K Models with Waiting time Distribution and their Steady State Solutions.

**Section-IV**
Bulk System with Input and Output Service. Bulk Models: $M^{(x)}/M//1$, $M/M^{(y)}/1$ and $M/M^{(a,b)}/1$ with Waiting time Distribution and their Steady State Solutions. Non-Markovian Queues: M/G/1, G/M/1 and $M/G^{(a,b)}/1$ Models with their Steady State Solutions and Waiting time Distributions.

**Books Suggested:-**


1. Medhi, J. : Stochastic Processes
2. Bailey, N.T.J. : Elements of Stochastic Process
3. Bhat, B.R. : Stochastic Models, Analysis and Applications
4. Pinsky, Mark A. and Karlin, Samuel : An Introduction to Stochastic Modeling
5. Gross & Hariss : Fundamentals of Queuing Theory
6. Kashyap, B.R.K. and Chaudhary, M.L. : An Introduction to Queuing Theory


**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## (b) (Agricultural Statistics) 17STA23D2

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 04 hrs per week.

**Paper Code: 17STA23D2**
**Paper: Agricultural Statistics**
**Course Outcomes**:

CO1: Able to understand and analyze the current issues and events that are occurring in agriculture.
CO2: Able to understand how employer characteristics and decision-making at various levels enhance the success of an agricultural enterprise.
CO3: Able to demonstrate critical thinking and problem solving skills as they apply to a variety of animal and or plant production systems.
CO4: Able to understand genetic variance.
CO5: Updated knowledge about utilization and growth trends of agricultural commodities.

**Section-I**

History of Agricultural Development in India. Current Production Utilization and Growth Trends of Agricultural Commodities In India. Crop Improvement: Plant Breeding Traditional and Contemporary Methods, Plant Classification, Description and Economic Use of Field Crops. Biotechnological Tools for Crop Improvement, Plant Genetics Resources, Seed Quality Control, Seed Production Methods, Seed Sowing Methods, Seed Stages. Crop Production: Modern Approaches of Management of Pest and Disease, Principles of Plant Pathology.

**Section - II**

Plant Science: Metabolic Processes and Growth Regulation, Climate Change, Reproduction, Post Harvest Physiology, Soil Environment Microbiology, Bio-Fertilizer. Useful Organism: Honey Bees and Bee Keeping, Lack Insect and Silk Worm. Horticulture: Fundamental of Horticulture, Orchards Management, Breeding of Horticultural Crops, Improvement of Fruit and Plantation Crops. Importance of Fruits and Vegetables In Human Nutrition. Contribution of Horticulture In National Economy and Export.

**Section - III**

Some Basic Genetical Terms, Statistical Analysis of Segregation, Detection and Estimation of Linkage. Gene and Genotypic Frequencies. Random Mating and Equilibrium In Large Populations. Disequilibrium Due To Linkages for Two Pairs of Genes and for Sex Linked Genes. Selection, Mutation and Migration. Equilibrium Between forces In Large Population. Polymorphism. Fisher's Fundamental Theorem of Natural Selection.

**Section - IV**

Polygenic Systems for Quantitative Characters, Concepts of Breeding Value, Dominance, Average Effect of Gene and Epistatic Interactions. Genetic Variance and Its Partitioning. Correlation Between Relatives. Regular System of Inbreeding, Effects of Inbreeding. Genotype and Environment Interaction, Stability Parameters.

**Books suggested:-**


| | | |
|---|---|---|
| Falconer, D.S. | : | Introduction to quantitative Genetics (Longman Group Ltd.) |
| Kempthorne, O (1953) | : | An Introduction to Genetical Statistics, Wiley Eastern |
| Prem Narain | : | Statistical Genetics, Wiley Eastern |
| ICAR | : | Handbook of Agriculture, ICAR Publication. |
| Jain, J.P. | : | Statistical Technique in Quantitative Genetics (Tata Mc Graw, Hill Publication Co. Ltd., New Delhi. |


**Note:** The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

# (c) (Official Statistics) 17STA23D3

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 17STA23D3**
**Paper: Official Statistics**
**Course Outcomes:**

CO1: Able to determine the basic principles and standards for the production and the organization of official statistics.
CO2: Became familiar with the production of current, reliable, timely, official statistics needed in all areas of national level.
CO3: Know statistical theory for gathering official statistics and providing an efficient and effective coordination between the institutions.
CO4: Able to improve official statistics using best professional standard and free from political interference.

**Section-I**

Introduction To Indian and International Statistical Systems. Present official Statistical Systems In India, Role, Functions and Activates of Central and State Organization. Organizations of Large Scale Sample Surveys Methods of Collection of official Statistics, Their Reliability and Imitations.

**Section-II**

General and Special Data Dissemination Systems, Population Growth In Developed and Developing Countries. Evaluation of Performance of Family Welfare Programs Projection of Labor force and Manpower. Scope and Content O Population of Census of India.

**Section-III**

System of Collection of Agricultural Statistics. Crop forecasting and Estimation. Productivity, Fragmentation of Holdings, Support Prices Buffer Stock. Principle Publications Containing Such Statistics.

**Section-1V**

Statistics Related To Industries, Balance of Payment, Cost of Living, Inflation, Educational and Other Social Statistics. Various Agencies Responsible for The Data Collection CSO, NSSO, office of Registrar General.

**Books Suggested:-**


1. Basic Statistics relating to the Indian Economy (CSO) 1990.
2. Statistical system in India (CSO) 1975.
3. Guide to official Statistics (CSO) 1999.
4. Principles and accommodation of National Populations Census UNESCO.
5. Panse, V.G., Estimation of crop Fields (FAO).


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

**16STA23C4-** Practicals (Based on **16STA23C1**) and will be of duration 3 hours.

**Paper Code: 16STA23C4**
**Paper: Practical's (Multivariate Analysis)- 16STA23C1**
**Course Outcomes:**

CO1: Able to extend the Univariate techniques to multivariate framework.
CO2: Ability to obtain mean vector and Variance-Covariance matrix for multivariate data.
CO3: Ability to find the estimate of population mean vector and dispersion matrix for multivariate normal distribution.
CO4: Know how to test the hypothesis for mean of multivariate population and to obtain confidence interval for it.
CO5: Ability to test hypothesis for correlation coefficient and regression coefficient for Null population

**16STA23C5 -**Practicals (Based on **16STA23C2))** and will be of duration 3 hours.

**Paper Code: 16STA23C5**
**Paper: Practical's (Designs of Experiments)- 16STA23C2**
**Course Outcomes:**

CO1: Able to analyze the experiment for CRD, RBD and LSD, for the significance of treatment means.
CO2: Ability how to estimate the missing observation effects and then analyze the data with adjusted degrees of freedom.
CO3: Ability to analyze the data from experiments using split plot and strip plot designs.
CO4: Ability to perform the analysis for test of treatments effects in $2^2$ factorial experiments.

The question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.
Distribution of marks will be as follows: -

| | | |
|---|---|---|
| Marks for Question Paper | : | 36 |
| Marks for Practical Record book | : | 06 |
| Marks for Viva-Voice | : | 08 |
| Total | : | 50 |

## Semester IV
## 17STA24C1 (Econometrics)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week.

**Paper Code: 17STA24C1**
**Paper: Econometrics**
**Course Outcomes:**

CO1: Able to understand regression analysis for analyzing the data.
CO2: Able to understand OLS estimators and their properties.
CO3: Able to know elementary procedures for model validation in the single equation context.
CO4: Able to understand theoretical background for the standard methods and properties of least squares estimators.
CO5: Acquainted with the concepts of multi-colinearity, autocorrelation, non normality & hetrosecdasticity.

**Section -I**

Two Variable Linear Regression Model- Least Squares Estimators of Coefficients and Their Properties, Inference In Least Squares Model, The General Linear Regression Model, Ordinary Least Squares Estimator and Its Properties, Inference In General Linear Regression Model. Generalized Least Squares Estimation

**Section-II**

Tests of Linear Restrictions On Regression Coefficients, Use of Extraneous Information On Regression Coefficients – Restricted Regression, Restricted Least Squares and Its Properties, Mixed Regression and Properties of Mixed Regression Estimator, Specification Errors Analysis- Inclusion and Deletion of Explanatory Variables, Effect On Estimation of Parameters and Disturbance Variance.

**Section -III**

Heteroscedasticity, Tests for Heteroscedasticity – Bartletts's, Breusch-Pagan and Goldfeld Quand t Tests Multicollinearity - Exact and Near Multicollinearity, Consequences and Detection of Multicollinearity , Farrar Glauber Test, Remedies for Multicollinearity, Ridge Regression Autocorrelation , Sources and Consequences, AR(1) Process Tests for Autocorrelation, Durbin Watson Test, Errors In Variables Model, Instrumental Variable Method of Estimation.

**Section -IV**

Simultaneous Equations Models: Structural and Reduced forms, Identification Problem. Rank and Order Conditions of Identification, Restrictions On Structural Parameters. Estimation In Simultaneous Equations Models: Recursive Systems, Indirect Least Squares 2SLS Estimators, Limited Information Estimators, K-Class Estimators,

**Books Recommended:**


1. Johnston, J. (1991): Econometric Methods, (Mc Graw Hill)
2. Greene, W.H. (2003) Econometric Analysis(Prentice Hall)
3. Damodar N. Gujarati(2004) Basic Econometrics, Fourth Edition (McGraw−Hill)
4. Koutsyannis, A (2004) Theory of Econometrics
5. Judge, G.C., Hill, R,C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988): Introduction to the Theory and Practice of Econometrics (Second Edition), John Wiley & Sons.


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 17STA24C2 (Inference- II)

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 17STA24C2**
**Paper: Inference II**
**Course Outcomes:**

CO1: Acquired knowledge of sequential test procedures, OC and ASN functions and to determine the functions.
CO2: Able to know Decision function, Risk function and Average Risk function, Admissible decision rules, Baye's risk and minimax risk.
CO3: Have theoretical background of pdf of order statistics as well as pdf of function of order statistics, and also the asymptotic distribution of order statistics.

CO4: Understand how to test one sample location problem using Sign test, Wilcoxom-Sign Test, K-S test. Also to test two samples location problems using K-S two sample test, Wald-wolfowitz test, Mann-Whiteney U test.

**Section- I**

Sequential Analysis; Sequential Testing Procedure, OC and ASN Functions, Wald's SPRT, Strength of SPRT and Determination of Its Stopping Bounds, Stopping Rule. Determinations of OC and ASN Functions of SPRT, Wald's Fundamental Identity and Its Use In The Derivation of ASN Function of SPRT.

**Section -II**

Basic Elements of Decision Theory: Decision Function, Risk Function, Rand omization, Optimal Decision Rules: Baye's and Minimax Decision Rule, The Least Favorable Distribution , Convex Loss Function. The form of Bayes Rules for Estimation Admissibility and Completeness. Existence of Minimal Complete Class.

**Section-III**

Non Parametric Theory: Concept of Non Parametric and Distribution Free Methods, Order Statistics , Their Marginal and Joint Distributions. Distributions of Median, Range and Coverage; Moments of Order Statistics. Asymptotic Distribution of Order Statistics.

**Section-IV**

Non Parametric Tests: One Sample and Paired Sample Problems. Ordinary Sign Test, Wilcoxon Signed Ranked Test, and Their Comparison. General Problem of Tied Differences. Goodness of Fit Problem : Chi-Square Test and Kolmogrov – Smirnov One Sample Test, and Their Comparison. Two Sample Problems: K-S Two Sample Test, Wald – Wolfwitz Run Test, Mann –Whiteney U Test, Median Test.

**BOOKS SUGGESTED**


1. Goon, A.M., M.K.Gupta, & B. Das Gupta : Outline of Statistics Vol-II
2. Kendall, M.G. and Straut, A. : Advanced Theory of Statistics
3. Rohtagi, V.K. : Theory of Mathematical Statistical
4. Rao, C.R. : Linear Statistical Inference and its applications


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## 17STA24C3 (Optimization Techniques-II)

Maximum Marks-80
Internal Assessment Marks-20
Time-03 Hours
Teaching Hours- 04 hrs per week

**Paper Code: 17STA24C3**
**Paper: Optimization Techniques II**
**Course Outcomes:**

CO1: Acquired knowledge for the solutions of Games by LPP techniques.
CO2: Able to describe and formulation Non Linear Programming Problems (NLPP).
CO3: Able to understand the difference between NLPP and LPP.
CO4: Acquainted with the methods for the solution of NLPP.
CO5: Able to obtain approximate solutions of restricted problems.

**Section –I**

Theory of Games: Characteristics of Games, Minimax (Maximin) Criterion and Optimal Strategy. Solution of Games with Saddle Point. Equivalence of Rectangular Game and Liner Programming. Fundamental Theorem of Game Theory. Solution of mxn Games by Linear Programming Method. Solution of 2X2 Games without Saddle Point. Principle of Dominance. Graphical Solution of (2xn) and (mx2) Games.

**Section –II**

Non-Liner Programming Problems (NLPP): formulation of NLPP. Kuhn-Tucker Necessary and Sufficient Conditions of Optimality and Saddle Points. Graphical Solution of an NLPP.

**Section –III**

Quadratic Programming : Wolfe's and Beale's Method of Solutions. Separable Programming and its Reduction to LPP. Separable Programming Algorithm. Geometric Programming: Constrained and Unconstrained. Complementary Geometric Programming Problems.

**Section –IV**

Fractional Programming and its Computational Procedure. Dynamic Programming: Balman's Principle of Optimality. Application of Dynamic Programming in Production, Linear Programming and Reliability Problems. Goal Programming and its formulation .Stochastic Linear Programming.

**Books Suggested:-**


1. Kambo, N.S. : Mathematical Programming Techniques.
2. Bellman, R. : Dynamic Programming (Princeton University Press, Princeton N.J. (1957)
3. Bellman, R. And Dreyfus, S. : Applied Dynamic Programming (Princeton University Press, Princeton, N.J. 1963)
4. Sinha, S.M. : Mathematical Programming (Theory and Methods)
5. Mitra, G. : Theory and Applications of Mathematical Programming
6. Bazaraa, M.S; Sherali,H.D.and Shetty, C.M. : Non-Linear Programming (Theory and Algorithms)


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

## Optional Paper
## (a) (Methods of Operations Research) 17STA24D1

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 17STA24D1**
**Paper: Methods of Operations Research**
**Course Outcomes:**

CO1: Ability to take optimum decisions/ solution to the executive type problems.

CO2: Able to form and solve deterministic and probabilistic inventory models and purchase inventory models with one, two and any number of price break.
CO3: Ability to solve job sequencing problem of N jobs through 2, 3 and M machines.
CO4: Demonstrate the ability to use process of simulation in inventory, queuing, finance etc.
CO5: Ability to use CPM and PERT methods in effective project management and how the crashing is done.

**Section –I**

Definition and Scope of Operations Research and Its Role In Decision-Making, its Characteristics, Phases, Different Types of Models, Their Construction and General Methods of Solution .Replacement Problem, Replacement of Items That Deteriorate, Replacement of Items That Fails Completely Individual Replacement Policy : Motility Theorems, Group Replacement Policy, Recruitment and Promotion Problems.

**Section –II**

Inventory Problems, Costs Involved In Inventory Problems, Classification of Inventory System. Deterministic and Probabilistic Inventory Models, Purchase Inventory Model, Purchase Inventory Model with One, Two and Any Number of Price Break.

**Section –III**

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) Simulation Definition, Types, Uses and Limitation of Simulation Phases, Simulation Models, Monte Carlo Simulation, Application of Simulation.

**Section –IV**

PERT/CPM: Development Uses and Application of PERT/CPM Techniques, Network Diagram Representation .Fulkerson 1-J Rule for Labeling Time Estimate and Determination of Critical Path On Network Analysis, PERT Techniques, Crashing.

## Books suggested:-


1. Churchman : Introduction to Operations Research, J. Wiley and Sons, New York
2. J.H.Taha : Method's of Operations Research, J. Wiley and Sons, New York
3. P. Sankara Iyer : Operation Research, Tata Mcgraw Hill
4. Sharma, S. D. : Operation Research, Kedar Nath Ram Nath, India


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each. Covering the whole syllabus and the candidate has to attempt all the questions.

## (b)(Actuarial Statistics) 17STA24D2

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching hours: 0 hrs per week

**Paper Code: 17STA24D2**
**Paper: Actuarial Statistics**
**Course Outcomes:**

CO1: Able to apply standard techniques of Mathematics and Statistics in order to address problems in actuarial science.

CO2: Able to identify and analyze consequences of events involving risk and uncertainty.
CO3: Apply appropriate modeling techniques to conduct quantitative risk analysis.
CO4: Use statistical software packages to solve actuarial problems.
CO5: Articulate the need for lifelong learning.

**Section-I**

Basic Concepts and Life Tables: Utility Theory, Insurance and Utility Theory, Models for Individual Claims and Their Sums, Survival Function, Curtate Future Lifetime, force of Mortality. Life Table and Its Relation with Survival Function, Examples, Assumptions for Fractional Ages, Some Analytical Laws of Mortality, and Select and Ultimate Tables. Multiple Life Functions, Joint Life and Last Survivor Status, Insurance and Annuity Benefits Through Multiple Life Functions Evaluation for Special Mortality Laws. Probability Models: Multiple Decrement Models, Deterministic and Rand Om Survivorship Groups, Associated Single Decrement Tables, Central Rates of Multiple Decrement, Net Single Premium and Their Numerical Evaluations.

**Section - II**

Distribution of Aggregate Claims Compounds Poisson Distribution and Its Applications. Principles of Compound Interest: Nominal and Effective Rates of Interest and Discount, force of Interest and Discount, Compound Interest, Accumulation Factor, Continuous Compounding. Life Insurance: Insurance Payable At The Moment's of Death and At The End of The Year of Death-Level Benefit Insurance, Endowment Insurance, Differed Insurance and Varying Benefit Insurance Recursions, Commutation Functions. Life Annuities: Single Payment, Continuous Life Annuities, Discrete Life Annuities, Life Annuities with Monthly Payments, Commutation Functions, Varying Annuities, Recursions, Complete Annuities-Immediate and Apportion Able Annuities-Due.

**Section- III**

Continuous and Discrete Premiums, True Monthly Payment Premiums, Apportionable Premiums, Commutation Functions and Accumulation Type Benefits. Payment Premiums, Apportion Able Premiums, Commutation Functions, Accumulation Type Benefits.Net Premium Reserves: Continuous and Discrete Net Premium Reserve, Reserves On A Semi Continuous Basis, Reserves Based On True Monthly Premiums, Reserves On An Apportion Able Or Discounted Continuous Basis, Reserves At Fractional Duration.

**Section –IV**

Allocations of Loss To Policy Years, Recursive formulas and Differential Equations for Reserves Commutation Function. Some Practical Considerations: Premiums That Include Expenses General Expenses Types of Expenses, Per Policy Expenses. Claim Amounts Distributions, Approximating The Individual Model, Stop-Loss Insurance.

**Books suggested:-**


1. Spurgeon E.T. Life Continuances, Cambridge university Press
2. Neil, A. Life Contingencies, Heinemann


Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C& D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

# (c) (Clinical Trials) 17STA24D3

Maximum Marks-80
Internal Assessment Marks—20
Time:-03 Hours
Teaching Hours: 04 hrs per week

**Paper Code: 17STA24D3**
**Paper: Clinical Trials (This course is not offered in this session)**
**Course Outcomes:**

CO1: Ability to understand some frequently used terms in clinical trials.
CO2: To identify and classify different types of designs in Pharmaceuticals Experiments.
CO3: Ability to identify and classify different types of trial designs when reading a trial report.
CO4: Ability to understand the essential design issues of randomized clinical trials.
CO5: Ability to understand the basic statistical principals, concepts and methods for clinical data analysis and reporting.

**Section-I**

Introduction, Motivation, and Ethics of Clinical Trials: Historical examples, Introduction to study designs and clinical trials, Ethics and Historically derived principles, Nuremberg Code, Declaration of Helsinki, Belmont Report. Equipoise, Informed consent. Phases, Contexts, Examples: Description of trial phases, Trial contexts and examples, Study Protocol: Introduction, background, Objectives ,Eligibility, Design, Rand omization, Intervention details, assessments and data collection, case report forms, Violations, Amendments. The Study Population and Cohort: Study population, Study cohort, Recruitment, Accrual, Inclusiveness and Representation .

**Section-II**

Study/Trial Design: Phase I designs, Dose-finding designs,Phase II designs, Pilot studies, Single arm ,Historical control designs,Phase III designs,Factorial designs,Crossover designs,Multicenter studies,Pilot studies,Phase IV designs. Treatment Allocation: Rand omization, Simple ,Blocked, Stratified,Adaptive allocation, Masking.

**Section-III**

Statistical Perspective: Philosophy, Bayesian vs. Frequentist. Research Question and Outcomes: Research Question, Surrogate Outcomes. Measurement and Data Capture: Measures and endpoints, Required observations,Types of measures, baseline measurements, Case report forms , Data collection, Paper or electronic, Parsimony, Database and software, Staffing and resources.

**Section-IV**

Data Monitoring, Trial Conduct: Data quality assurance, Data delinquency, Data Monitoring, Trial Conduct, Occurrence and control of variation and bias. Introduction to Power and Sample Size: Hypothesis testing, P-values, confidence intervals, General power/sample size, estimating effect size, Matching sample size calculations to endpoints. Regulatory Affairs: Misconduct and fraud Conflict of interest.

**Books Suggested:-**


1. Piantadosi, S (1997) Clinical Trials: A methodological Perceptive, Wiley & Sons.
2. Friedman, L.M. FurBurg, C.and Demets.D.L. (1998) Fundamentals of Clinical trials, Springer Verlag.
3. Fleiss, J.L. (1989) the Design and Analysis of Clinical Experiments, Wiley and Sons.
4. Marubeni, E.and Valsecchi, M.G. (1994) Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
5. Jelkison cand .Turnbull, B.W. (1999) Group sequential with application to Clinical Trials, CRC Press.

6.

Note: The examiner is to set the question paper into five units- A, B, C, D & E. In each unit A, B, C & D, he/she has to set two questions of 16 marks each from section I, II, III, & IV respectively and the candidate will attempt one question from each unit. In unit E, there will be 8 short answered questions of 2 marks each, covering the whole syllabus and the candidate has to attempt all the questions.

**17STA24CL3-** Practicals (Based on **17STA24C3)** and will be of duration 3 hours.

**Paper Code: 17STA24CL3**
**Paper: Practical's (Optimization Techniques-II-17STA24C3)**
**Course Outcomes:**

CO1: Achieved experience for the use of LPP techniques to solve Game problems.
CO2: Able to understand computational techniques for the solutions of NLPP'S.
CO3: Demonstrate ability to find out applications of NLPP in industries and management.

**17STA24C4-**Practicals (Based on **17STA24C1 & 17STA24C2)** and will be of duration 3 hours.

**Paper Code: 17STA24C4**
**Paper: Practical's (Econometrics & Inference-II-17STA24C1 & 17STA24C2)**
**Course Outcomes:**

CO1: Able to understand regression analysis for analyzing the data.
CO2: Acquainted with the concepts of multi-colinearity, autocorrelation, non normality & hetrosecdasticity.
CO3: Ability to test one sample and two samples location problems using Non Parametric Tests.
CO4: Ability to test hypothesis using sequential procedures and to obtain ASN and OC functions of SPRT, and plot them.
CO5: Ability to find Bayes Rule, Minimax Rule, Admissible Decision Rules, Bayes' Risk and Minimax Risk.

The question paper will consist of five questions and the student will be required to attempt any three questions. The question paper will set on the spot jointly by the Internal and External Examiner.
Distribution of marks will be as follows: -

| | | |
|---|---|---|
| Marks for Question Paper | : | 36 |
| Marks for Practical Record book | : | 06 |
| Marks for Viva-Voice | : | 08 |
| Total | : | 50 |