

# **STATISTICS**

## **M. A./M. Sc. (Previous & Final)**

M.A./M.Sc. (P) Four papers of theory each of 100 marks and practical of 200 marks in two sessions (100 marks of each session).

Theory papers I, II & III are compulsory and one optional paper from papers VII, VIII, IX, X, XI, XII and XIII.

M. A./M. Sc (F) four papers of theory each of 100 marks and Practical of 200 marks in two sessions (100 marks of each session).

Theory papers IV, V, & VI are compulsory and one optional (not offered in M. Sc. (P) Statistics) paper from papers VII, VIII, IX, X, XI, XII, XIII and XIV.

Notes :—1. Optional papers are to be chosen with the approval of the Head of the Department of Statistics of the college.

2. Optional paper XIV can be offered in M. Sc. (F) Statistics only.

### **M. A./M. Sc. Statistics (Compulsory papers)**

- Paper I. Statistical Mathematics.
- Paper II. Probability and Distributions.
- Paper III. Matrix Algebra & Design of Experiments.
- Paper IV. Multivariate analysis and Sample Survey.
- Paper V. Statistical Inference.
- Paper VI. Linear Programming and Operations Research.

### **(Optional Papers)**

- Paper VII. Economic Statistics
- Paper VIII. Engineering Statistics



- Paper IX. Demography.  
 Paper X. Stochastic Process & Queueing Theory.  
 Paper XI. Bio-Assays and Genetics.  
 Paper XII. Psychometric Method and Sociometry.  
 Paper XIII. Fortran Programming.  
 Paper XIV. Project work Dissertation and viva-voce.

### **Practicals :**

#### *For Previous Examination :*

Two sessions of four hours each : 100 marks each session.

**Session I** - Practical problems based on paper III (Matrix Algebra and Design of Experiment).

**Session II**—Practical problems based on paper I (Statistical Mathematics), Paper II (Probability and distributions) and optional paper offered for M.A./M.Sc. previous examination.

#### *For Final Examination*

Two sessions of four hours each : 100 marks of each session.

**Session I**—Practical Problems based on Paper IV.

(Multivariate Analysis and Sample Surveys).

**Session II**—Practical Problems based on Paper V

(Statistical Inference), VI (Linear Programming and Operational Research) and Optional offered for M.A./M.Sc. final examination except paper XIV (Project work).



## **Paper I**

### **Statistical Mathematics**

Limits, continuity of functions of one Variable, differentiability, Mean Value Theorems, Taylor's Theorem with the statement of Various remainder terms, Maxima-Minima of functions of many Variables (method of undetermined multipliers only), Jacobians.

Riemann integration, Fundamental theorem and Mean Value theorems of Integral calculus, Infinite integrals with tests of convergence, differentiation and integration under integral signs. change of order of integration, Beta and Gamma Integrals.

Double, Multiple Integrals, Dirichlet's Integral, uniform convergence of series including the continuity of sum functions of the series term, by term differentiability and integrability of series.

Regular functions, its construction and properties, differentiation and Integration, Taylor's and Laurent's series, theory of residuals, Contour integration, Various interpolation formula, central differences, Numerical quadrature formulas. with remainder terms Numerical differentiation, Inverse interpolation, Summation of series, Elementary difference equations—Linear equations of first order, Exact equation of first order, linear difference equation with constant coefficients.

### **Books Recommended :**

1. Rudin W—Principles of Mathematical Analysis.
2. Shanti Narain—A course of Mathematical Analysis.
3. Nirvikar Saran—Real Analysis.
4. Shanti Narain—Theory of complex Variables.
5. Philips E. G.—Functions of complex Variable with Applications.
6. Freeman—Finite Differences for Actuarial Students.



- 7: Richardson—Calculus of Finite Differences.
8. H. C. Saxena—Examples in Finite Differences and Numerical analysis.
9. Goon. Gupto & Das Gupta—Fundamental of Statistics Vol I (Sixth Revised Edition)

## ***paper II***

### **Probability and Distributions**

Algebra of sets, limits of a sequence of sets. Classes of sets—ring, field and  $\sigma$  field, monotone classes, Minimal field and  $\sigma$  field, Borel field. Measure and probability measure.

Axioms of probability, Addition, and Multiplication theorems of probability, Probability of 'm' event out of 'n' events.

Random Variables - discrete and continuous, distribution function and probability density function.

Joint distribution of several random variable, Mathematical expectation and moments, Inequalities for moments - Holder's, Minkowski's and Chebyshev's inequalities.

#### **Books Recommended :**

Cauchy, Beta, Gamma and Bivariate Normal distributions. probability generating function, moment generating function, Cumulant generating function, and characteristic function of random variables, Inversion (Uniqueness) and continuity theorem for characteristic functions.

Convergence in probability, almost sure convergence and convergence in distribution, convergence in quadratic mean of a sequence of random variables and their inter relationships.



Tchebychcfff's inequality, Markov inequality and Kolmogorov's inequality, Weak and Strong law of large numbers. Central limit theorems-Lindeberg Levy and Liapounoff's theorems.

Distributions of function of random variables, Distribution of sample mean and sample variance, distributions of Chi-square, Student's t and Fisher's F and Z.

Order statistics-distribution of extreme order statistics, range and Kth order statistics of a sample.

### Books Recommended :

1. Fis, M. : Probability theory and Mathematical statistics
  2. Feller, W : An introduction to probability theory and its application Vol. I
  3. Cramer, H. : Mathematical Methods of statistics
  4. Wilks, S.S. : Mathematical Statistics
  5. Bhatt, B.R. : Modern probability theory
  6. Goon, M.A. : An Outline of statistical theory Vol I
- Gupta, M.K.  
& Dasgupta, B

### Paper III

#### Matrix Algebra and design of Experiment

Finite dimensional vector spaces, existence of basis, linear transformations, algebra of matrices, rank and inverse of a matrix, solution of linear equations, characteristic roots and characteristic vectors, orthogonal matrices, Gram-Schmidt orthogonalisation method.



Quadratic forms and their reduction, Cochran's theorem, congruence and similarity of matrices.

Linear estimation, Markoff's theorem, test of a linear hypothesis, analysis of variance and covariance.

Principle of experimentation, Analysis of C. R. D, R. B. D. and L. S. D, Orthogonal Latin Squares.

Factorial experiments ( $2$ ,  $3^2$ ,  $3^3$  system only) Complete and partial Confounding.

Analysis of Balanced incomplete Block designs, Simple and Balanced Lattices, Split plot Design, Missing, plot techniques.

### **Books Recommended :**

1. Halmos, P.R. : Finite Dimensional vector spaces
2. Saxena, H.C. and : Theory of Matrices  
Sharma, K.L.
3. Shanti Narayan : Theory of Matrices
4. Searle : Linear Models
5. Kempthorne, O. : The design and analysis of experiments
6. Cochran and Cox : Experimental Design

## **Paper IV**

### **Multivariate Analysis and Sample Surveys**

Multivariate normal distribution, Marginal and Conditional distributions. Distribution of quadratic forms, Distribution of second order moments and sample correlation coefficient  $r$  for  $P=0$ , Distribution of partial and multiple correlation coefficients in the null case.

Wishart's distribution, Hotelling's  $T^2$  and Mahalanobis  $D^2$

Discriminant function [ for two populations only ] canonical correlation.  
Principal components.

Basic principles in Sample survey, enquiries, choice of sampling units,  
Simple random sampling, stratified random sampling-proportional and  
optimum allocation methods.

Ratio and Regression methods of estimation, Systematic sampling and  
Double sampling.

Cluster sampling, Multistage sampling [for units of equal size], Non-  
sampling errors, Interpenetrating sub-samples, Non-response.

### **Books Recommended :**

1. Anderson, T.W. : Multivariate Analysis
2. Kendal, M.G. : A course of Multivariate Analysis
3. Sukhatme, P.V. and : Sampling theory of survey  
Sukhatme, B.V.
4. Cochran, W. G. : Sampling Techniques
5. Des Raj : Sample Surveys
6. Goon MA, Gupta MK, : An Outline of Statistical Theory Vol II  
and Das Gupta, B



## **Paper V**

### **Statistical Inference**

Concepts of consistency, efficiency, sufficiency and unbiasedness. Derivation of uniformly minimum variance unbiased estimates. Method of the Cramer—Rao and Bhattacharya bounds. Method of complete sufficient statistics, Rao—Blackwell theorem.

Maximum likelihood and other methods of estimation. Existence of best asymptotically normal estimates under regularity conditions.

Confidence interval, Neyman's approach, best confidence intervals.

Size and power of a test, Locally and uniformly most powerful tests, Neyman-pearson's fundamental lemma, Randomized tests. Monotone Likelihood Ratio. Regions of Type A,  $A_1$  and B regions. Unbiased tests and use of complete sufficient statistics for construction of such tests. Likelihood ratio test.

Element of theory of games and principles of choice of decisions, Admissible decisions, Bayes and minimax decision rules.

Simple non parametric:—One sample Wilcoxon signed-rank, paired-sample sign, paired sample, Wilcoxon signed-rank, Two Sample Wilcoxon rank sum, Two sample Mann-Whitney.

Elements of Sequential test procedure, Sequential probability ratio test for a simple hypothesis against a simple alternative, its properties. Operating characteristic function, Average Sample Number function of sequential probability ratio test, Efficiency of sequential probability ratio test, SPRT for testing parameters of Binomial, Poisson, Exponential and Normal distributions.



**Books Recommended :**

1. Goon, M.A , Gupta M.K, and : An Outline of statistical theory,  
Das Gupta, B. Vol. II
2. Rao, C.R. : Linear statistical inference and its applications
3. Black well, D. and : Theory of Games and Statistical Decisions  
Girshick, M.C.
4. Kendall, M.G. : The advanced theory of Statistics Vol. II.
5. Free man, D.H. : Introduction to Statistical Inference
6. Lehman, E.L. : Testing of Statistical Hypothesis
7. Fraser, D.A.S. : Non-parametric methods in Statistics
8. Wald, A. : Sequential Analysis
9. Gibbons, J.D. : Non-parametric Statistical Inference
10. Lehman, E.L. : Point-Estimation

**paper VI****Linear Programming and Operations Research**

Connex Sets and their properties, Separating and Supporting Hyperplanes.  
Linear Programming and its formulation, Graphical solution, Theory  
of Simplex Method, Simplex Algorithm.

Duality in linear Programming, Dual Simplex Algorithm, Revised Simplex



Method, Degeneracy, Zero sum-two person games, Saddle point, optimal strategy, minimax theorem for rectangular games.

Assignment Problem : Reduction Theorem. Hungarian method, Assignment Algorithm Routing problem, Travelling Salesman problem, Inventory Control : Carrying, shortage and replenishing costs, types of inventory systems, inventory policies, demand and replenishment properties simple deterministic order level systems. Probabilistic order level system.

Transportation Problem and its Variations U-V method, Transportation Algorithm, Degeneracy in transportation.

Replacement and Maintenance : Replacement of Capital equipment in anticipation of failures, Inspection of emergency equipment.

Sequencing of n-jobs through two and three machines.

PERT and Critical Path Method (C.P.M.)

### **Books Recommended :—**

1. Gass, S. L. : Linear Programming—Methods and Applications.
2. Shrinath : Linear Programming.
3. Lomba, N. P. : Linear Programming—An Introductory Analysis.
4. Kanti Swaroop, P.K.,  
Gupta & Man Mohan : Operations Research.
5. Ackoff; R.L., and  
Sasieni, M. W. : Fundamentals of Operations Research.
6. Naddor, R. : Inventory System.
7. Mackinsey : Theory of Games.
8. Churchman, Ackoff  
and Arnoff : Introduction to Operations Research.



9. S. Vajda : An Introduction to Linear Programming and the theory of Games.

10. Sasieni, Yaspan and Friedman : Operations Research—Methods and Problems

## ***paper VII***

### **Economic Statistics**

**Time Series** : General idea of Time Series, Models, Components; Trend and its measurement ; Method of free hand curve fitting, Methods of Mathematical curves (Polynomial Trend), Orthogonal Polynomials, Method of Moving averages, Iterated average methods, Spencier's 15 point formula, Spencier's 21 point formula. Non Parametric tests for the Trend.

**Seasonal and its measurements :**

Cyclic movements ; fourier analysis Periodogram analysis.

Non-Parametric test for Cyclical fluctuation.

Random or irregular fluctuations ;

Variate difference Method.

Auto-correlation.

Serial correlation and correlogram.

Wald Wolfowitz Non-Parametric Test.

Stochastic Difference equation (Linear autoregression)

Determination of the constants  $a$  and  $b$  in the autoregressive equation.

Correlogram Analysis—Moving averages, Periodic and Autoregressive schemes.



*Econometrics* : General idea, Econometric models Dummy Variable, Proximate variable, Lagged variable. Endogeneous and exogeneous variables.

Single equation (Linear) Model ;

Multiple equation model ; and their estimation method Cobweb Model and its Extensions.

Simultaneous equation model ; Structural and Reduced form, Concept of Identification (Linear, Economic Model). Rank and order conditions (in simple cases only).

Indirect least square methods, 2S, L, S and 3S, L, S. (brief outlines only, without any derivations).

Input-Output analysis.

### **Books Recommended :**

1. Kendall, M. G. & Stuart A : Advanced Theory of Statistics.
2. Tintner, G. : Econometrics.
3. Allen, R. G. D. : Mathematical statistics.
4. Maddala, G. S. : Econometrics
5. Christ, C. F. : Econometric Model and Methods.
6. Tintner, G. : Variate Difference Methods.
7. Goldberger, A.S. : Econometric Theory.

## **Paper VIII**

### **Engineering Statistics**

*Quality Control* : Fundamentals, Objectives, Application of Probability distributions.

*Shewarts Charts* : Charts For variables (Mean, Range and - charts) ; Charts for attributes (p-chart and c-chart etc.) ; Modified control limits.



*Acceptance sampling for attributes* :—Fundamental concepts, Acceptance Quality Control Level (A. Q. C. L.), Lot Tolerance Percentage Defectives (L. T. P. D.), Single sampling plans for attributes, Dodge and Roming type system for acceptance sampling by attributes.

*Double and Sequential sampling plans for attributes* : O. C. of double and sequential sampling plans, A. S. N. functions of sampling plans.

*Acceptance sampling for variables* : Singles sampling plans, sampling procedures and tables for inspection by variables for percent defective, acceptance procedure from testing of hypothesis point of view.

*Quality Engineering* : Design of Quality assurance, Special Quality experiments, Quality management. Economics of quality. Quality Control education.

### **Books Recommended :**

1. Grant, E. L. : Statistical Quality Control.
2. Ekambaran, S. K. : The Statistical Basis of Acceptance Sampling.
3. Ekambaram, S. K. : The Statistical Basis of Quality Control Charts.
4. Dodge, H.F. & Roming H.G. : Sampling Inspection tables.
5. Rice : Control Charts.
6. Burr : Industrial Quality Control.
7. Brown Lee : Industrial Experimentation.
8. Hansen, B. L. : Quality Control Theory and Applications.



**Paper-IX****Demography**

Vital Statistics and population studies, method of standard population measurement of morbidity Statistics.

Growth of population productions, various rates and ratio and their uses, Registration method of births and deaths in India, Population census in India, utility, forecasting, uses of logistic curves.

*Fertility* : Measures and Trend.

*Mortality* : Death rates and causes.

*Mortality Indices* : Life tables, construction of life tables from census, force of mortality.

*Actuarial Statistics* : Nominal and effective rates of interest amount and present values of annuities, Loan repayable by instalments, expectation of life, Life and Endowment policies.

*Migration and distribution of population* : Migration and demographic analysis, definition of migration, internal and international migration, Measuring the volume of migration. Indirect measurement (Census and Vital Statistics).

*Manpower and working activities* : Source of data, definition of economic activity, Types of economic activities.

**Books Recommended:**

1. Core : Demography.
2. Barclay : Techniques of Population Analysis.
3. Kamithan and Bhende : Principles of Population Studies.
4. Hooker & Cook : Life and Other Contingencies.
5. Benjamin : Elements of Vital Statistics.



**PAPER X****Stochastic Process and queueing theory**

*Stochastic Process* : Definition of a stochastic process and examples, Counting process and Poisson process, Normal-process and Wiener process.

*Markov Chains – Discrete Parameter* : Definition of Markov Process, Transition probabilities and Chapman Kolmogorov equation, Ergodicity, Limit theorems for transition probabilities for a finite Markov chain.

*Markov Chains-Continuous Parameter* : Limit theorems for transition probabilities of a continuous parameter of Markov Chain, Birth and Death Processes, Kolmogorov differential equations for the transition probability functions.

*Queueing Theory* : Description of queues, characteristics of queueing systems, classification of queues, definition of transient and steady states, Poisson queues.

**Deterministic and Probabilistic Models, solution of—**

- ( i ) M/G/1 system,
- ( ii ) M/M/1 system, finite and infinite case,
- ( iii ) M/M/K system,

Transient solution of M/M/1 system (infinite). Monte Carlo Solution.

**Books Recommended :**

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|---------------------|---|
| 1. Karlin, S.,      | : First Course in Stochastic Processes,   |
| 2. Parzen, E.       | : Stochastic Processes,   |
| 3. Bailey, N. T. J. | : The Elements of Stochastic Processes with applications to the natural Sciences. |
| 4. Takacs, L.       | : Combinatorial Methods in the theory of Stochastic Processes.                    |



5. Saaty, T. L. : Elements of Queueing Theory.
6. Cox, D. R. & Smith, W. L. : Queues.
7. Kanti Swaroop, Gupta, P. K. : Operations Research and Man Mohan.

## ***paper XI***

### **Bio-Assays and Genetics**

Quantal and Quantitative type of bio-assays, Tolerance distribution, Probit and angular transformation, Adjustment for natural mortality.

Dosage response curve and relationship, Maximum likelihood estimation in problems of Probit Analysis, Direct assays, Slope Ratio assays.

Mendelian theory of inheritance, Autosomal and chromosomal inheritance for one or more characters with and without linkage, Gene and genotypic frequencies. Detection and estimation of linkage.

Random mating, Hardy vein berg law. Forces affecting gene frequency, mutation, migration, selection, coeff of relationship and inbreeding polygenic system, Quantitative characters components of variation.

Human genetics, General specific combining abilities, Hetroses, Estimation of repeatability, Heritability, Genetic correlation.

### **Books recommended :**

1. Finney : Statistical Methods in Bio-Assay.
2. Finney : Probit Analysis.
3. Kempthorne : Genetic Statistics.
4. Mather : Mesurement of Linkage in Heredity.



**Paper XII****Psychometric Method And Sociometry**

Basic concepts of Statistics as applied to Psychometry, Intelligence and Personality tests-their standardisation and reliability.

Application of canonical correlation and Hotellings most prediction, Factor analysis, Spearman's two factors theory, Hotellings methods, Centroid method, Lawley's and Barttells method of estimation of factors.

Item selection to maximise the test variance, reliability correlation analysis, Rank correlation methods, Biserial correlation values.

Basic concept of Sociometry, various designs applicable to social and sociometric surveys and enquiries.

Scales and Sociogram's quantitative treatment of qualitative data measurements of trials of variables, Model construction and analysis of attitude changes, scales, nominal rank and internal scales.

**Books Recommended**

1. Garret : Statistics in Psychology and Education.
2. Ferguson : Statistical Analysis in Psychology and Education.
3. Guilford & Fruschter : Fundamental Statistics in Psychology and Education
4. Horowitz : I Element of statistics is for Psychology and arithmetic
5. Nunnaly : Introduction to statistics for Psychology Education

**paper XIII****Fortran Programming**

Elements of the Fortran language-constants variables and arithmetic expressions and functions.



The Basic Fortran language, Arithmetic control, input, output, specification and subprogramming, statements.

Arithmetic statement, functions, defining and calling functions, sub-routines and sub programming construction of flow charts.

Writing fortran programme for the following problems, Solution of simultaneous equations, Evaluation of determinants, Inversions of matrices,

Determination of roots of a polynomial, Solution of linear and polynomial regression, computation of total, partial and multiple correlation and moments analysis variance.

### Books Recommended :

1. M. C. Craken and Dorn : Numerical methods of and fortran programming
2. M. C. Cermic and Salvadori : Numerical Methods in Fortran

## Paper XIV

### Project Work/Dissertation And Viva-Voce

The project work shall be based on either primary data involving field work of Secondary data. The candidate will be required to prepare critical report on the same.

Note:—Paper XIV will be assessed jointly by Internal and External Examiners.

Distributions of marks will be as follows:-

(i)	Internal assessment	40 marks
(ii)	External assessment	40 marks
(iii)	Viva-Voce	20 marks