

*SYLLABUS FOR THE THREE YEAR*  
*B.Sc.(Honours) COURSE*

**IN**

**STATISTICS**

**(Approved by the Under-Graduate Board of Studies)**



**West Bengal State University**  
**(Barasat, NORTH 24 PARGANAS)**

*With Effect From The*  
**ACADEMIC SESSION 2008-2011**

# Course Structure

## **Part I Examination: Total marks- 200** (Theoretical –150 marks +Practical- 50 marks)

### **Theoretical – 150 marks**

Paper –I: Full marks -100

Group -A : Mathematical Methods I (25 marks)

Group –B : Probability Theory I (25marks)

Group –C : Descriptive Statistics (50marks)

Paper – II Full marks – 100

Section -I (50 marks)

Group – A : Indian Statistical Systems,  
Economic Statistics (20marks)

Group –B : Population Statistics (30 marks)

### **Practical-50 marks**

Section – II (50 marks)

Practical based on topics in Papers I & II (Section I) (40 marks)

Viva Voce ( 5 marks)

Practical Notebook ( 5 marks)

## **Part II Examination : Total marks -200** (Theoretical 150 marks + Practical 50 marks )

### **Theoretical –150 marks**

Paper- III : Full marks -100

Group –A : Mathematical methods II (25 marks)

Group –B : Probability Theory II (40marks)

Group –C : Sampling Distributions &  
Statistical Inference I (35 marks)

Paper -IV : Full marks -100

Section -I (50 marks)

Group –A : Time Series Analysis (25 marks)

Group –B : Statistical Quality Control (25 marks)

**Practical-50 marks**

**Section – II (50 marks)**

Practical based on topics in

Papers III & IV (Section I) (40 marks)

Viva Voce ( 5 marks)

Practical Notebook ( 5 marks)

**Part III Examination : Total marks - 400**

**(Theoretical 200 marks + Practical 200 marks)**

**Theoretical –200marks**

Paper V : Full marks – 100

Group A :Multivariate Distributions &  
Large Sample theory (40 marks)

Group –B : Statistical Inference II (60 marks)

Paper VI : Full marks – 100

Group A :Analysis of Variance &  
Design of Experiments (60 marks)

Group –B :Sample Survey Methods (40 marks)

**Practical -200 marks**

Paper -VII Full marks –100

Section –I :Based on topics in Paper V (40 marks )

Section –II : Based on topics in Paper VI (40 marks )

Viva Voce (10 marks)

Practical Notebook (10 marks)

Paper -VIII : Full marks –100

C Programming (50 marks)

Use of Statistical Packages (30 marks)

Viva Voce (10 marks)

Practical Notebook (10 marks)

## Detailed Syllabus

(L denotes lecture hours)

### Paper I

#### Group A : Mathematical Methods I

Vector Algebra : Vector spaces with real field ,Basis dimension of vector space. Orthogonal vectors, Gram –Schmidt Orthogonalization. (7L)

Matrix Algebra :Linear transformation and Matrices. Matrix operations. Elementary matrices and their uses. Rank of a matrix and related results.Inverse of a matrix. Determinants.The Sweep –out and Pivotal Condensation methods. Characteristic roots and vectors.Quadratic forms –classification and canonical reduction. (16L)

Systems of Linear Equations :Homogeneous and Non –homogeneous systems – conditions of solvability. (2L)

Sequences and Series of functions :Pointwise convergence.Uniform convergence and Absolute convergence.Simple tests of convergence.Power series. Taylor series expansion. (5L)

Integration :Improper integrals. Beta and Gamma integrals. (2L)

#### ***References :***

- 1.Hadley G. (1995) :Linear Algebra, Addison Wesley/ Narosa
- 2.Rao A. R. & Bhimasankaran P (1996) :Linear Algebra
- 3.Searle S.R. (1982) :Matrix Algebra –useful for statistics, John Wiley
- 4.Roa C.R. (1974) :Linear Statistical Inference &its Applications, Wiley
- 5.Hoffman & Kunze R. (2001) :Linear Algebra
- 6Goon A.M. (1988) : Vectors and Matrices
- 7.Apostol T. M. (1985) : Mathematical Analysis, Narosa
8. Apostol T. M (1968) : Calculas (Vol 1 & 2)
- 9.Goldberg R.R. (1953) : Methods of Real Analysis, Oxford &IBH Pub Co
- 10.Widder D. V. (1994) : Advanced Calculas
- 11.Piskunov N. (1977) : Calculas (Vol 1& 2)
12. Malik S.C. & Arora S (1991) : Mathematical Analysis

#### Group B : Probability Theory I

Random Experiment : Trail.Sample point. Sample space. Different types of events. Concept of  $\sigma$  -algebra of events. (5L)

Definition of probability :Classical and relative –frequency approach to probability. Kolmogorov's Axiomatic definition (detailed discussion on discrete space only), limitations of classical definition . Probability of union and intersection of events.

Probability of occurrence of exactly  $m$  and atleast  $m$  events out of  $n$  events. Conditional probability and independence of events , Bayes' Theorem and its applications. Examples based on classical approach and repeated trials. (20L)

Random Variables : Definition of discrete and continuous random variables, cumulative distribution function (c.d.f.) and its properties (with proof ), probability mass function (p.m.f.) and probability density function (p.d.f.). Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles. (7L)

### **References :**

1. Chung K.L.(1983) : Elementary Probability Theory with Stochastic Process, Springer International Edition /Narosa
- 2.Feller W.(1968) :An introduction to Probability Theory & its application, John Wiley
- 3.Goon A.M. ,Gupta M.K. & DasGupta B. (1994) :An Outline of Statistical Theory (Vol –1),World Press.
- 4.Rohatgi V.K. (1984) : An introduction to Probability Theory & Math. Statistics, John Wiley
- 5.Hoel P.J. ,Port S.C. &Stone C.J. : Introduction to Probability Theory (Vol-1) Houghton Mifflin &UBS
- 6.Cramer H. (1954) :The Elements of Probability Theory , John Wiley
- 7.Parzen E. (1972) :Modern Probability Theory and its application, John Wiley
- 8.Uspensky J.V. (1937) : Introduction to Mathematical Probability and its application, John Wiley
- 9.Cacoullos T. (1973) : Exercises in Probability, Narosa
- 10.Rahman N.A. (1983) : Practical Exercises in Probability and Statistics,Griffen
- 11.Pitman J.(1993) : Probability, Narosa
- 12.Stirzaker D.(1994) : Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001) : A First Course in Probability, Narosa
14. Bhat B.R. (1999) : Modern Probability Theory , New Age International

### **Group C : Descriptive Statistics**

Introduction : Name of Statistics. Uses of Statistics. Statistics in relation to other disciplines, Abuses of Statistics. (2L)

Types of Data :Concepts of population and sample, quantitative and qualitative data, cross-sectional and time series data,discrete and continuous data, different types of scales. (3L)

Collection and Scrutiny of data : Primary data- designing a questionnaire and a schedule, checking its consistency. Secondary data- its major sources. Complete enumeration, Controlled experiments, Observational studies and Sample Surveys. Scrutiny of data for internal consistency and detection of errors in recording. Ideas of cross- validation. (4L)

Presentation of data :Construction of Tables with one or more factors of classification, diagrammatic representations, frequency distributions and cumulative frequency distributions and graphical representations, stem and leaf displays. (6L)

Analysis of Quantified data :

Univariate data – different measures of location , dispersion, relative dispersion, Skewness and kurtosis. Moments and Sheppard's correction for grouped data ( without proof) Quantiles and measures based on them –comparison with moment measures. Gini's coefficient. Lorenz curve. Box Plot. (17L)

Bivariate data – scatter diagram, correlation coefficient and its properties. Correlation ratio . Correlation Index. Intraclass correlation with equal and unequal group sizes.

Principles of least squares, regression curves and related results, fitting of polynomial and exponential curves. Rank correlation –Spearman's and Kendall's measures. (15L)

Analysis of categorical data : Consistency of data, independence and association of attributes, measures of association-Pearson's  $\chi^2$ , Yule's  $Y$  and Tschuprow's  $T$  measures. Goodman-Kruskal's  $\gamma$ . Somer's  $d$ . Kendall's  $\tau$  and  $\tau_p$ . Cramer's  $v^2$ .  $\alpha$  and  $\delta$  measures, odd ratio, (10L)

### ***References :***

1. Goon A.M., Gupta M.K, DasGupta B.(1998) :Fundamentals of Statistics(V-1).  
World Press
2. Yule G.U. & Kendall M.G.(1950) : An introduction to the Theory of Statistics.  
C. Griffin
3. Kendall M.G. & Stuart A.(1966) : Advanced Theory of Statistics (Vols 1&2)
4. Snedecor & Cochran(1967) :Statistical Methods (6<sup>th</sup> ed), Iowa State Univ. Press
5. Croxton F.F., Cowden D.J. & Klein (1969) : Applied General Statistics,  
Prentice Hall
6. Wallis F.E.& Roberts H.V. (1957) : Statistics-a new approach. Methuen
7. Tukey J.W.(1977) : Exploratory Data Analysis, Addison-Wesley Pub. Co.
8. Lewis Beck M.S.(ed.)(1993) :Regression Analysis, Sage Publications
9. Garret H.E.(1966) : Statistics in Psychology and Education. Longmans
10. Guilford. J.P. (1954) :Psychometric Methods. McGraw Hill
11. A. Agresti (1984) :Analysis of ordinal Categorical Data

## **Paper II**

### **Section-I**

#### **Group A : Indian Statistical Systems & Economic Statistics**

##### **Indian Statistical System:**

The Statistical System in India :the central and state Government organizations, the functions of the Central Statistical Organization (CSO), the National Sample Survey

Organization (NSSO) and West Bengal Bureau of Applied Economics and Statistics.(6L)  
Sources of Official Statistics in India and West Bengal relating to  
:population,agriculture, industry , trade, price, and employment. (2L)  
Brief ideas of National Income statistics. (2L)

### **Economic Statistics. :**

Index Numbers :Price, Quantity and Value indices. (2L)  
Price Index Numbers :Construction, Uses,Limitations, Tests for index numbers,Various  
formulae and their comparisons,Chain index numbers. (8L)  
Some Important Indices :Consumer Price Index, Wholesale Price Index and Index of  
Industrial Production – Methods of construction and uses. (4L)

### **References :**

- 1.C.S.O. (1984) : Statistical System in India
- 2.Goon A.M. ,Gupta M.K. & DasGupta B.(2001) : Fundamentals of Statistics(V-2).  
World Press
3. Yule G.U. &Kendall M.G.(1953) : An introduction to the Theory of Statistics.  
C. Griffin
4. Kendall M.G. & Stuart A.(1966) : Advanced Theory of Statistics(Vol 3),  
C.Griffin
5. Croxton F.F., Cowden D.J. &Klein (1969) : Applied General Statistics,  
Prentice Hall
- 6.Mudgett B.D.(1951) :Index Numbers. John Wiley
7. Allen R.G.D.(1975) : Index Numbers inTheory and Practice. Mcmillan
- 8.Mukhopadhyay P. (1999) :Applied Statistics
- 9.Johnson J. &Dinardo J.(1997) :Econometric Methods. McGraw Hill
- 10Nagar A.I. &Das R.K. (1976) :Basic Statistics.

### **Group B : Population Statistics**

Introduction : Sources of Population Data –Census data, Registration data and the errors  
in such data . Rates and ratios of vital events. (3L)  
Measurements of Mortality :Crud Death rate , Spetic Death rate. Standardized Death  
rate, Cause of Death rate ,Infant Mortality rate, Maternal Mortality rate, Neonatal and  
Perinatal Mortality rates. (8L)  
Life tables : Descriptions of Complete and Abridged Life tables and their uses. Coroht vs  
Current life tables. Stable population Stationary population. Constrtuction of complete  
life table from population and death ststistics. (8L)  
Measurement of Morbidity : Crude Birth rate, General Fertility rate, Age Specific  
Fertility rate, Total Fertility rate. (4L)  
Measurement of Population Growth : Crude rate of Natural Increase and Vital Index,  
Gross and Net reproduction rates. (4L)

Population Estimation, Projection and Forecasting : Use of A.P. and G.P. methods for population estimates, Use of Component Method for population projection, fitting of Logistic curve for population forecasting using Rhode's and Fisher's methods. (10L)

**References :**

1. .Goon A.M. ,Gupta M.K. & DasGupta B.(2001) : Fundamentals of Statistics(V-2).  
World Press
- 2.Spiegelman M. (1980) : Introduction to Demography, Harvard Univ. Press
- 3.Cox P.R.(1976) : Demography.
- 4.Biswas S. (1988) :Stochastic Processes in Demography and Applications.
5. Mishra B.D. (1980) : An Introduction to the Study of Population.  
South Asian Pub.

**Paper III**

**Group A : Mathematical Methods II**

- Approximation of numbers and functions, Absolute and Relative errors. Weirstrass Theorem(Statement Only) (2L )
- Interpolation : Polynomial approximation, Difference Table, Newton's Forward and Backward interpolation formulae and Lagrange's general interpolation formula, Error terms. (7L)
- Numerical Differentiation and its application. (2L)
- Numerical Integration :Trapezoidal and Simpson's 1/3 rules. (3L)
- Numerical solution of equations :method of fixed point iteration and Newton –Raphson method in one unknown, Conditions of convergence, rates of convergence. Extension of the iteration method to two unknowns. (5L)
- Stirling's approximation to factorial. (1L)
- Maxima and Minima : Maxima and minima for functions of several variables, Constrained maximization and minimization –use of Lagrange multiplier. (3L)
- Integrals : multiple integrals, Transformation variables and Jacobian, Polar and Orthogonal transformations, Dirichlet's integral. (7L)

**References :**

1. Scarborough J.B. (1958) : Numerical Mathematical Analysis, Oxford Univ. Press
2. Atkinson K. (1985) : Elementary Numerical Analysis
3. Sastry S.S. (1998) : Intoductory Methods of Numerical Analysis
4. Hildebrand F.B. (1974) : Introduction to Numerical Analysis, Tata McGraw-Hill
5. Apostol T.M. (1985) : Mathematical Analysis, Narosa
6. Apostol T.M. (1968) : Calculas (Vols 1&2)
7. Goldberg R.R. (1953) :Methods of Real Analysis, Oxford&IBH Pub. Co.
8. Widder D.V. (1994) : Advanced Calculas



9. Piskunov N. (1977) : Calculus (Vol 1&2)
10. Malik S. C.& Arora S. (1991) :Mathematical Analysis

**Group B : Probability Theory II**

The c.d.f., p.m.f. and p.d.f. in bivariate case. Marginal and Conditional distributions. Independence. Conditional Expectation. Correlation and Regression. (15L)  
 Generating Functions :Probability Generating function and moment Generating function in univariate and bivariate cases. (5L)  
 Probability Inequalities : Chebyshev's Lemma, Markov's & Chebyshev's inequalities. (5L)

Limit Theorems : Convergence in Probability, Weak Law of Large Numbers and its applications, Convergence in Distribution. De-Moivre-Laplace Limit Theorem, Normal approximation to the Poisson distribution,Statement of Central limit Theorem (i.i.d. case) &its application. (10L)

Univariate Discrete Distribution : Uniform, Bernoulli, Binomial, Hypergeometric, Poisson,Negative Binomial, Geometric and Power series distributions and their properties. (7L)

Univariate Continuous Distributions : Rectangular, Normal, Cauchy, Gamma, Beta, Exponential, Laplace, Logistic, Pareto, Lg-normal distributions and their properties. (Use of continuous distributions in scaling and the Pareto and Log- normal distributions as income or allied distributions ) (8L)

Truncated distributions. (2L)

Bivariate Normal Distribution and its properties. (5L)

***References :***

1. Chung K.L.(1983) : Elementary Probability Theory with Stochastic Process, Springer International Edition /Narosa
2. Feller W.(1968) :An introduction to Probability Theory & its application, John Wiley
3. Goon A.M. ,Gupta M.K. & DasGupta B. (1994) :An Outline of Statistical Theory (Vol -1),World Press.
4. Rohatgi V.K. (1984) : An introduction to Probability Theory & Math. Statistics, John Wiley
5. Hoel P.J. ,Port S.C. &Stone C.J. : Introduction to Probability Theory (Vol-1) Houghton Mifflin &UBS
6. Cramer H. (1954) :The Elements of Probability Theory , John Wiley
7. Parzen E. (1972) :Modern Probability Theory and its application, John Wiley
8. Uspensky J.V. (1937) : Introduction to Mathematical Probability and its application, John Wiley
- 9.Cacoullos T. (1973) : Exercises in Probability, Narosa

10. Rahman N.A. (1983) : Practical Exercises in Probability and Statistics, Griffen
11. Pitman J. (1993) : Probability, Narosa
12. Stirzaker D. (1994) : Elementary Probability, Cambridge University Press
13. Chandra T.K. & Chatterjee D. (2001) : A First Course in Probability, Narosa
14. Bhat B.R. (1999) : Modern Probability Theory, New Age International

### **Group C : Sampling Distributions & Statistical Inference I**

#### **Sampling Distributions:**

Concepts of Random Sampling. Statistic and Sampling distributions of Statistics. Illustrations using different distributions, reproductive properties of the distributions. (7L)

Some standard Sampling Distributions :  $\chi^2$  distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions, distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population, distribution of simple regression coefficient (for both stochastic and non-stochastic independent variable cases). (10L)

Distribution of order statistics and Sample Range. (3L)

#### **Statistical Inference I:**

Elements of Estimation : Concepts of Point and Interval Estimation; Requirements of a good estimator - notions of Mean Square Error, Unbiasedness, Minimum Variance, Best Linear Unbiasedness, Methods of Estimation – method of moments and Least –square method. Confidence Intervals. (6L)

Elements of Hypothesis Testing : Null and Alternative hypotheses, Simple and Composite hypotheses, Critical Region, Type I and Type II Errors, Level of Significance and Size, p-value, Power. (4L)

Applications : Estimation, Tests of Significance and associated Confidence Intervals related to a single Binomial proportion and Poisson parameter, two Binomial proportions and Poisson parameters, the mean and variance of an univariate normal distribution, the difference of means and ratio of variances of two independent normal distributions, the difference of means, the ratio of variances and the regression and correlation coefficients of a bivariate normal distribution. (10L)

#### **References :**

1. . Goon A.M. ,Gupta M.K. & DasGupta B. (1994) :An Outline of Statistical Theory (Vol –1),World Press.
2. John N. I. & Kotz S. (1970) :Distributions in Statistics, John Wiley
3. Ross S.M. (1972) : Introduction to Probability Models, Academic Press
4. Mood A.M., Graybill F. & Boes D.C. (1974) : An Introduction to the Theory of Statistics (3<sup>rd</sup>ed), McGraw Hill

5. Rao C.R. (1952) : Advanced Statistical Methods In Biometric Reach,  
John Wiley
6. Hogg R.V. & Craig A.T. (1978) : Introduction to Mathematical Statistics
7. Rohatgi V.K. (1984) : An Intro. to Probability Theory & Math. Statistics,  
John Wiley
8. Stuart G. & Ord J.K (1991) : Advanced Theory of Statistics (Vol 2). C. Griffin
9. Goon A.M. , Gupta M.K. & DasGupta B. 1997) : Fundamentals of Statistics (V-1).  
World Press
10. Keeping E.S. (1962) : Introduction to Statistical Inference, East West Press
11. Bhattacharya G.K. & Johnson R.A. (1977) : Concepts & Methods Of Statistics,  
John Wiley

### **Paper IV**

#### **Section-I**

#### **Group A : Time Series Analysis**

- Introduction : Examples of time series from various fields. Components of time series .  
Additive and Multiplicative models. (2L)
- Trend and Seasonal Components : Estimation of trend by linear filtering (simple weighted moving averages) and curve fitting (polynomial, exponential and Gompertz ).  
Variate Difference method. Detrending. Estimation of seasonal component by ratio to moving –average method, ratio to trend method. Deseasonalization. (10L)
- Stationary Time Series : Weak stationarity. Autocorrelation. Function and Correlogram.  
Test for Randomness (Kendall's  $\tau$  ). (4L)
- Some special processes : Moving –average (MA) process and Autoregressive (AR) process of orders one and two. Estimation of parameters of AR(1) and AR(2) –Yule-Walker equations. (10L)
- Forecasting : Exponential smoothing and Holt- Winters method. (4L)

#### ***References :***

1. Kendall M.G. (1976) : Time Series, Charles Griffin
2. Chatfield C. (1980) : The Analysis of Time Series- An Introduction  
Chapman and Hill
3. Mukhopadhyay P. (1999) : Applied Statistics
4. Johnston J. & Dinardo J. (1997) : Econometric Methods, McGraw Hill

#### **Group B : Statistical Quality Control**

- Introduction : Concepts of Quality and Quality Control, Process Control and Product Control (5L)
- Process Control : Control Charts And their uses, Choice of Subgroup sizes,  
Construction of  $\bar{x}$ , R, s.d., np charts, p and c charts with variable sample sizes,  
Interpretation of non-random pattern of points, Modified Control Charts. (10L)

Product Control : Producer's Risk, Consumer's Risk, Acceptance Sampling Plan, Single and Double sampling plans by attributes, OC, ASN ( and ATI ), LTPD and AOQL, Single sampling plan for inspection by variables (one-sided specification, known and unknown  $\sigma$  cases ), Use of IS plans and tables. (10L)

**References :**

- 1.Goon A.M.,Gupta M.K.,DasGupta B. (2001) : Fundamentals of Statistics (V-2)  
World Press
- 2.Duncun A.J. (1953) : Quality Control and Industrial Statistics, Richard D Irwin
- 3.Cowden D.J. (1957) :Statistical method in Quality Control, Prentice Hall
- 4.Grant E.L.& Leavenworth (1964): Statistical Quality Control, McGraw Hill
- 5.Bowley A.H. &Goode H.P. (1952) : Sampling Inspection by Variables,  
McGraw Hill
- 6.Ekambaram S.K. (1960) : The Statistical Basis Quality Cont. Charts,  
Asia Pub. Hoome
- 7.Montgomery D.C. (1985) : Introduction to Statistical Quality Control,  
John Wiley
- 8.IS2500 Part I& Part II
9. Bureau of Indian Standards (1994) : Handbook of Statistical quality Control
10. Indian Standards Institution (1982): Manual on Basic Principles Lot Sampling

**Paper V**

**Group A : Multivariate Distributions & Large Sample Theory**

**Multivariate Distributions :**

Multivariate data – multiple correlation and partial correlation and their properties, multiple regression and related results.

Regression with count data: Logistic regression and fitting by iterative methods. (8L)

Random Vector : Probability mass and density functions, Distribution Function, Mean Vector and Dispersion matrix, Marginal and Conditional Distributions, Ellipsoid of Concentration, Multiple Regression, Multiple Correlation , Partial Correlation. (8L)

Multivariate Distributions : Multinomial, Dirichlet and Multivariate Normal distributions and their properties. (6L)

## Large Sample Theory:

Derivation of large sample standard error of sample moments, standard deviation, coefficient of variation,  $b_1$  and  $b_2$  measures and correlation coefficient and their uses in large sample tests. (8L)

Transformations of Statistics to stabilize variance : derivation and use of  $\sin^{-1}$ , square root, logarithmic and z- transformations. (4L)

Large sample tests for binomial proportions, Poisson means (single and two independent sample cases) and correlation coefficients. (3L)

Large sample distribution of Pearsonian  $\chi^2$  –statistics and its uses. Yate's correction in a  $2 \times 2$  contingency table. (5L)

## References:

- 1.Kendall M.G. & Stuart A. (1996) : Advanced Theory of Statistics (Vol 3) C.Griffin
- 2.Anderson T.W. (1958) : Multivariate Analysis
3. Goon A.M.,Gupta M.K.,DasGupta B. (1994) : An Outline of Statistical Theory (Vol 1&2 ), World press
- 4.Rohatgi V.K. (1984) : An Intro. To Probability Theory &Math. Statistics, John Wiley
- 5.Jonston N.I.&Kotz S. (1970) : Diistributions in Statistics, John Wiley
- 6.Serfling R.J. (1980) Approximation theory of Math. Statistics, John Wiley
- 7.Chandra T.K. (1999) :A First Course in Asymptotic Theory in Statistics, Narosa
- 8.Hogg R.V.& Craig A.T. (1978) : Introduction to Mathematical Statistics
- 9.Rao C.R. (1974) : Linear Statistical Inference and its Applications, John Wiley
10. Mukhopadhyay P. (1996) : Mathematical Statistics
11. Lewis –Beck M.S. (edt.) (1993) :Basic Statistics, Sage Publication

## Group B : Statistical Inference II

Point Estimation : Sufficiency, Completeness, Factorization Theorem, Exponential Family of distributions, Properties of minimum variance unbiased estimators, consistent estimators and asymptotic efficiency , Cramer –Rao lower bound .Rao- Blackwell Theorem. Lehmann- Scheffe Theorem. Maximum Likelihood Minimum  $\chi^2$  estimators and their properties (excluding proofs of large sample properties ). (20L)

Theory of Hypothesis Testing : Most Powerful(MP), Uniformly Most Powerful (UMP) and Uniformly Most Powerful Unbiased (UMPU) tests, Randomized and nonrandomized Tests,Fundamental Neyman –Pearson Lemma (sufficiency part only), and its use in the construction of Mp and UMP tests (single parameter with range independent of the parameter ), Combination of Probabilities in tests of significance , Likelihood Ratio tests and its applications to tests for the equality of means and variances of several normal populations. Sequential tests for simple hypothesis against simple alternatives, Expressions of OC and ASN functions (without proof). (25L)

Interval Estimation : Confidence intervals Confidence sets, Concepts of Uniformly Most Accurate (UMA) and Uniformly Most Accurate Unbiased (UMAU) confidence sets, relationship with tests of hypotheses, confidence intervals with Shortest Expected Length. (5L)

Nonparametric Methods : Sign test, Median test, Wilcoxon Signed-Rank test, Run test, Mann-Whitney U test, Confidence limits for Quantiles, Tolerance limits. (10L)

### ***References :***

1. . Goon A.M.,Gupta M.K.,DasGupta B. (1994) : An Outline of Statistical Theory (Vol 2 ), World press
- 2.Mood A.M.,Graybill F.&Boes D.C. (1974) : An Intro. to the Theory of Statistics (3<sup>rd</sup> ed ). McGraw Hill
3. Hogg R.V.& Craig A.T. (1978) : Introduction to Mathematical Statistics
4. Rao C.R. (1974) : Linear Statistical Inference and its Applications, John Wiley
5. Rohatgi V.K. (1984) : An Intro. To Probability Theory &Math. Statistics, John Wiley
- 6.Kale B.K. (1999) : A first Course in Parametric Inference, Narosa
7. Mukhopadhyay P. (1996) : Mathematical Statistics
- 8.Santhakumaran A.(2001) : Fundamentals of Testing Statistical Hypotheses, Atlantic Pub

## **Paper VI**

### **Group A : Analysis of Variance & Design of Experiments**

#### **Analysis of Variance (ANOVA)**

Heterogeneity and Analysis of Variance and Covariance, Linear Hypothesis, Orthogonal splitting of total variance, Selection of Valid Error. (4L)

Applications of the ANOVA technique to : one-way classified data, two-way classified data with number of observations per cell, testing simple regression coefficients, correlation ratio, linearity of simple regression, multiple correlation and partial correlation coefficients. (12L)

Design of Experiments: Principles of Experimental Design: Randomization, Replication and Local Control, Uniformity trials, Shapes and Sizes of Plots and Blocks. (4L)

Standard Designs and their Analyses : Completely Randomised Design (CRD), Randomised Block Design (RBD), Latin Square Design (LSD), Split Plot Design and Strip arrangements, comparison of efficiencies. Applications of the techniques of Analysis of variance to the analysis of the above designs. (18L)

Groups of Experiments using RBD and LSD. (3L)

Factorial Experiments : 2<sup>n</sup> experiments, Advantages, Total and Partial Confounding, Analysis. (10L)

Analysis of Covariance (ANCOVA) : Application of the ANCOVA technique to one-way classified data to two-way classified data with number of observations per cell, use in control of error in CRD, RBD and LSD. (5L)

Missing Plot Technique: Analysis with one missing plot in a RBD and in a LSD. (4L)

**References :**

1. Scheffe H. (1959) : The Analysis of Variance, John Wiley
2. Kempthorne O. (1965) : The Design and Analysis of Experiments. Wiley Eastern
3. Das M.N. & Giri N.C. (1986) : Design and Analysis of Expts. (2<sup>nd</sup>ed).  
Wiley Eastern
4. Montgomery D.C. (1976) : Design and Analysis of Experiments, John Wiley
5. Cochran W.G. & Cox G.M. (1957) : Experimental Designs. John Wiley
6. Federer W.T. (1975) : Experimental Designs – Theory and Application. Oxford & IBH
7. Goon A.M., Gupta M.K., DasGupta B. (2001) : Fundamentals of Statistics (V-2)  
World Press
8. Mukhopadhyay P. (1999) : Applied Statistics

**Group B : Sample Survey Methods**

Concepts of a Finite population and a sample, Need for Sampling, Complete Enumeration and Sample Surveys. (3L)

General Ideas : Planning and execution of sample surveys, analysis of data and reporting , Biases and Errors. Judgement and probability sampling. Tables of random numbers and their uses. (5L)

Basic sampling and Estimation Procedures : Simple random sampling with and without replacement, Stratified random sampling, Linear and Circular Systematic Sampling, Cluster Sampling, two-stage (with equal-sized first stage units ) sampling with selection probabilities at each stage. Associated unbiased estimators of population total, mean and proportion , their variances and unbiased variance estimators. Determination of sample size in simple random sampling, Allocation problem in stratified random sampling and optimum choice of sampling and sub-sampling fractions in two-stage sampling, Interpenetrating sub-sampling technique for unbiased variance estimation in systematic sampling. (25L)

Ratio and Regression methods of estimation in simple random sampling. Double sampling for ratio and regression estimators. (5L)

Randomised Response Techniques : Warner's Model. (2L)

**References :**

1. Goon A.M., Gupta M.K., DasGupta B. (2001) : Fundamentals of Statistics (V-2)  
World Press

2. Murthy M.N. (1977) : Sampling Theory and Methods , Statistical Pub. Soc., Calcutta
3. Des Raj & Chandhok P. (1998) : Sample Survey Theory, Narosa Pub. House
4. Cochran W.G. (1984) : Sampling Techniques (3<sup>rd</sup> ed), Wiley Eastern
5. Mukhopadhyay P. (1998) : Theory and Methods of Survey Sampling , Prentice Hall
6. Sukhatme P.V. & Sukhatme B.V.(1970) : Sampling Theory of Surveys with Applications, Asia Pub. House
7. Sampathy S. (2001) : Sampling Theory and Methods, Narosa
8. NSSO Publications

### **Paper VII**

The practical examination for the two sections I and II, of Paper VII will be held on two separate days each of four hours duration.

### **Paper VIII**

#### **Introduction to Computers:**

Positional Number System, Binary arithmetic, Data representation. Basic Hardware units, Computer Languages, Operating System, Algorithm and flow chart. (5L)

#### **Computer Programming:**

Elements of C Language: Structure of C –program, ‘C’ character set, constants and variables, C-operators, decisions making and looping, general form of function. Library functions and header files, Input/Output functions, Arrays, Use of pointers, Files.

Illustration through the following programming problems:

1. Computation of summary measures in statistics
2. Selection sorting : Computation of quantiles
3. Computation higher order moments : Coefficients of Skewness & Kurtosis
4. Computation of correlation coefficient for ungrouped data
5. Fitting of regression equations to a given data set
6. Factorial of a positive integer ( $\leq 7$ )
7. Fitting of Binomial and Poisson & Truncated distributions
8. Transpose, addition, multiplication, determinant, trace, inverse of square matrices and solution of linear equations
9. Interpolation by Lagrange’s formula
10. Numerical Integration: Trapezoidal and Simpson’s 1/3 rule (Convergence included)
11. Solution of numerical equations by Newton Raphson and iteration methods in one unknown



12. Computation of Spearman's rank correlation coefficient (no tie situation )
13. Generation of samples from Binomial, Exponential, Normal ,Chi square, t and F distributions. (40L)

**Use of Statistical Software:**

**MS Excel**

1. Use of spreadsheet
2. Drawing of diagrams—  
Bar, Columns, Line, Pie, Scatter
3. Use of functions : Mathematical, Statistical and Logical
4. Line diagrams showing different types of time series data, determination of trend by moving averages and curve fitting methods plotting fitted values.
5. Exponential Smoothing of a time series (5L)

**MINITAB**

Use of MINITAB package using the options under 'CALCULATION ' and 'STATISTICS' .

**Some suggested problems:**

1. Basic statistics – Display descriptive measures (univariate and bivariate ), one sample z and t tests, Two sample and paired t tests , Tests for proportion, Tests for one and two variances and correlations.
2. Regression : Linear and multiple regression – fitted and residual plots, Binary Logistic regression.
3. ANOVA –One way and two way classified data.
4. Design of Experiments – Factorial
5. Control Charts -- Mean –Range, Mean- SD, proportion, number of defectives, number of defects charts. (10L)

***References :***

1. Fundamentals of Computers : V. Rajaraman; Prentice Hall of India
2. C Language and numerical methods: C Xavier; New Age International
3. The C programming language : Kernighan B. W. and Ritchie D.M. ; Prentice Hall