**DEPARTMENT OF STATISTICS**
UNIVERSITY COLLEGE OF SCIENCE
OSMANIA UNIVERSITY, HYDERABAD – 500 007

**M.Sc. APPLIED STATISTICS**
**CBCS** - SCHEME OF INSTRUCTION AND EXAMINATION
**WITH EFFECT FROM 2016 – 2017**

**SEMESTER I**

| Paper | Sub. Code | Paper Title | Instruction Hrs/ Week | Duration of Exam (in Hrs) | Max. Marks | IA and Assign. | Credits |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| I | STAS1-I | Linear Algebra and Linear Models (LA and LM) | 4 | 3 | 80 | 20 | 4 |
| II | STAS1-II | Probability Theory (PT) | 4 | 3 | 80 | 20 | 4 |
| III | STAS1-III | Distribution Theory and Estimation (DT and ET) | 4 | 3 | 80 | 20 | 4 |
| IV | STAS1-IV | Sampling Theory and Surveys (ST) | 4 | 3 | 80 | 20 | 4 |
| **PRACTICALS** | | | | | | | |
| V | STAS1-V | C++ Programming | 8 | 3 | 100 | *** | 4 |
| VI | STAS1-VI | Linear Algebra, Linear Models, Distribution Theory, Estimation and Sampling Theory (LA, LM, DT, ET, ST) | 8 | 3 | 100 | *** | 4 |
| **Total** | | | 32 | *** | 520 | 80 | 24 |
| **Semester Total** | | | | | 600 | | |

M.Sc. (Applied Statistics) Semester I

**STAS1- I :** Paper I - Linear Algebra and Linear Models (LA and LM)

UNIT – I

Vector Spaces with an inner product, Gram –Schmidt orthogonalization process.Orthonormal basis and orthogonal projection of a vector. Moore penrose and generalized inverses and their properties. Solution of matrix equations. Sufficient conditions for the existence of homogeneous and non – homogeneous linear equations.

UNIT–II

Characteristic roots and vectors, Caley–Hamilton theorem algebraic and geometric multiplicity of a characteristic root and spectral decomposition of a real symmetric matrix. Real quadratic forms, reduction and classification of quadratic forms, Index and signature .Simultaneous reduction of two quadratic forms, Extreme of a quadratic form. Matrix Inequalities: Cauchy- Schwartz and Hadamard Inequalities.

UNIT – III

Formulation of a linear model through examples. Estimability of a linear parametric function. Guass-Markov linear model, BLUE for Linear functions of parameters, relationship between BLUEs and linear Zero-functions. Gauss Markov theorem, Aitkens generalized least squares. Concept of Multicollinearity.

UNIT – IV

Simple Linear regression – precision of the estimated regression, examining the regression equation - lack of fit and pure error. Analysis of multiple regression model, estimation and testing of regression parameters, Sub-hypothesis. Testing a general linear hypothesis., Multiple and partial correlations - derivation and testing. Use of dummy variables in multiple regression. Polynomial regression- Use of orthogonal polynomials

REFERENCES


1. Graybill, F.A. (1983) : Matrices with applications in Statistics, 2nd ed., Wards worth.
2. Searle, S.R.(1982) : Matrix Algebra useful for Statistics, John Wiley & Sons.
3. Rao, C.R. and Mithra, S.K.(1971) : Generalized inverse of matrices and its applications, John Wiley & Sons.
4. Rao, A.R. and Bhimasankaram, P. (1992) : Linear Algebra, Tata McGraw Hill Publishing Co. Ltd.
5. Draper and Smith:Applied Regression Analysis ,John Wiley
6. Montgomery :Introduction to Linear Regression Analysis .John Wiley.
7. Searle, S.R.(1982) : Linear models, John Wiley & Sons.
8. Kshirsagar.A.M. (1972) : A Course in Linear Models.

M.Sc. (Applied Statistics) Semester I

**STAS1-II :** Paper II - Probability Theory (PT)

UNIT – I

Review axiomatic approach to Probability, Probability as a measure, conditional probability (and Baye's Theorem). Random Variable, distribution function and its properties. Riemann – Stieltjes integration, Statement of properties of Riemann – Stieltjes integrals, Examples. Expectations of functions of random variables – moments. Conditional expectation and conditional variances, applications (A list model, random graph, uniform priors, Polyas' urn model and Bose-Einstein distribution, mean time for patterns, the compound Poisson identity, the k-record values of discrete random variables).

UNIT – II

Characteristic function and its properties, Uniqueness theorem and Inversion theorem, examples. (Functions which can not be Characteristic functions). Statement of Levy's continuity theorem. Probability and moment inequalities **:** Chebychev's, Markov, Cauchy-Schwartz, Holder, Minkowsky, Liapunov and Jensen Inequalities.

UNIT – III

Sequence of random variables – Borel-Cantelli Lemma; Borel 0-1 law. Convergence of sequence of random variables – convergence in law; convergence in probability; convergence in quadratic mean; convergence with probability one (almost sure convergence); Their implications and/or counter implications; Slutzky's theorem and its applications. Statement of Glivenko-Cantelli lemma.

UNIT – IV

Weak law of large numbers – Bernoulli and Khintchine's WLLNs. Kolmogorov inequality. Strong law of large numbers – Borel's SLLNs. Kolmogorov's SLLNs for independent random variables and i.i.d. random variables, examples.

Central Limit Theorem – Demoviere-Laplace form of CLT, Levy-Lindeberg form of CLT, Liapunov's form of CLT and Statement of Lindberg – Feller form of CLT – examples.

REFERENCES


1. Bhat, B.R. (1985) : Modern Probability Theory – Wiley Eastern.
2. Rohatgi, V.K. (1993): An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern
3. Ross, S.M (2004) : Introduction to Probability Models, 8th Edition (Chapter 3) – Academic Press
4. Chandra, T.K. and Chatterji D (2001) : A First Course in Probability, Narosa Publishing House
5. Milton and Arnold – Introduction to probability and Statistics (4th Edition)-TMH publication.


ADDITIONAL REFERENCES


1. Karlin, S and Taylor, S.J. (1975) : A First course in Stochastic Processes, Academic Press.

M.Sc. (Applied Statistics) Semester I

**STAS1- III :** Paper III - Distribution Theory and Estimation (DT and ET)

UNIT – I

Review of Univariate Discrete and Continuous distributions. Cauchy, Lognormal, Weibull, Pareto, Laplace distributions and their properties. Compound distributions (Binomial and Poisson only). Truncated distributions (Poisson, Exponential and Normal distributions). Mixture Distributions. Bivariate Normal distribution.

UNIT – II

Functions of random variables and their distributions using Jacobian of transformations and Characteristic function. Sampling Distributions of Sample mean and variance, independence of $\overline{X}$ and $S^2$. Central t, F and $\chi^2$ distributions and their properties. Non-central $\chi^2$, t and F distributions and their properties (Statements only). Distributions of Quadratic forms under normality. Joint and Marginal Distributions of order statistics. Distributions of sample range and quantile.

UNIT – III

Concepts of point estimation - MSE, unbiasedness, sufficient statistic, relative efficiency, consistency of point estimate. Statement of Neymann's factorization criterion with applications, MVUE, amount of information, Cramer-Rao lower bound and its applications. Rao–Blackwell theorem, completeness, Lehmann – Scheff's theorem.

UNIT – IV

Method of moments, minimum chi square, Least Squares, MLE and its properties (statements only). Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, apriori, aposteriori distributions, conjugate families, Baye's and minimax decision functions with applications to estimation with quadratic loss.

REFERENCES


1. Rohatgi,V.K. (1984) : An Introduction to Probability theory and Mathematical Statistics, Wiley Eastern.
2. Dudewicz,E.J. and Mishra,S.N. (1988) : Modern Mathematical Statistics, Wiley International, Students Edition.
3. Parimal Mukhopadhya: Mathematical Statistics.
4. Milton and Arnold – Introduction to probability and Statistics (4th Edition)- TMH publication.


ADDITIONAL REFERENCES


1. Ferguson, T.S. (1967) : Mathematical Statistics, A decision theoretic approach, Academic Press.
2. Rao,C.R.(1973) : Linear Statistical Inference and its applications,2/e, Wiley Eastern.
3. Johnson,S. and Kotz (1972) : Distribution in Statistics, Vol. I,II and III.
4. Lehman, E.L. (1983) : Theory of Point Estimation, John Wiley and Sons.

M.Sc. (Applied Statistics) Semester I

**STAS1- IV :** Paper IV - Sampling Theory and Surveys (ST)

## UNIT – I

Review of SRSWR, SRSWOR, Stratified random sampling and Systematic Sampling. Unequal probability Sampling – Probability proportional to size (PPS) sampling with and without replacements (ppswr / wor) methods - drawing samples using Cumulative total and Lahiri's methods. Horwitz -Thompson, Hansen – Horwitz and Yates and Grundy estimators for population mean, total and their variances.

## UNIT – II

Ratio Method of Estimation - Concept of ratio estimators, Ratio estimators in SRS, their bias, variance/MSE. Ratio estimators in Stratified random sampling – Separate and combined estimators, their variances/MSE.

Regression method of estimation – Concept Regression estimators, Regression estimators in SRS with pre–assigned value of regression coefficient (Difference Estimator) and estimated value of regression coefficient, their bias, variance/MSE, Regression estimators in Stratified Random sampling – Separate and combined regression estimators, their variances/ MSE.

## UNIT – III

Cluster Sampling - Cluster sampling with clusters of equal sizes, estimator of mean per unit, its variance in terms of intracluster correlation coefficient, determination of optimum sample and cluster sizes for a given cost. Cluster sampling with clusters of unequal sizes, estimator of population mean and its variance/MSE.

Sub sampling (Two–Stage only) - Equal first stage units – Estimator of population mean, variance/MSE, estimator of variance. Determination of optimum sample size for a given cost. Unequal first stage units – estimator of population mean and its variance/MSE.

## UNIT – IV

Planning of Sample Surveys - Methods of data collection, problem of sampling frame, choice of sampling design, pilot survey, processing of survey data.

Non-sampling errors - Sources and treatment of non-sampling errors. Non – sampling bias and variance.

## REFERENCES


1. Parimal Mukhopadhyay (1998) : Theory and methods of Survey sampling, Prentice – Hall of India, New Delhi.
2. Cochran, W.C. (1977) : Sampling Techniques, Third Edition, Wiley Eastern.
3. Daroga Singh and Chowdary (1986) : Theory and Analysis of Sample Survey Designs – Wiley Eastern Ltd.


## ADDITIONAL REFERENCES


1. Des Raj (1976) : Sampling Theory, Tata McGraw Hill, New Delhi.
2. Sukhatme et. Al (1984): Sampling Survey methods and its applications, Indian society of Agricultural Statistics.
3. Murthy, M.N. (1967) : Sampling theory, Tata McGraw Hill, New Delhi.

M.Sc. (Applied Statistics) Semester I

**STAS1- V :** Paper V - Practical (C++ Programming)

**Concepts to be covered -** Principles of Object Oriented Programming, Tokens, Expressions and Control structures. Functions, classes and objects. Constructors and destructors. Operator overloading and type conversions, Inheritance, Pointers, Virtual functions and Polymorphism. Managing console I/O operations. Working with files. Object oriented system development. Templates and exception handling.

**List of Practicals:**

1) a) Factorial of a number b) Fibonacci series generation
2) a) Pascal triangle b) Pyramid of digits
3) Evaluation of a) $e^x$ b) sin x c) cos x using series expansion.
4) Find a) mean b) variance c) standard deviation and d) coefficient of variation for a given set of data.
5) a) Finding correlation coefficient and b) fitting straight line regression and parabolic regression curve.
6) Sorting numbers by bubble sort and finding median and mode of the data.
7) Write a program for preparation of frequency tables using functions and computing mean, median, mode, variance and standard deviation of the frequency distribution.
8) Write a class to a) crate a vector b) modify the values of a given element c) to multiply by a scalar value and d) display the vector in the form of a row vector. Write a main program to test your class.
9) Display and addition of complex numbers and vectors by creating a complex and vector class, respectively.
10) Matrix addition, subtraction and multiplication of confirmable matrices by operator over loading.
11) Concatenation of two strings using operator overloading.
12) File opening, writing records, reading records and updating a file, prepare merit list of students for an entrance examination marks from a file. Write the merit list on some other file and display the same.
13) Define a base class 'B' containing one private data member 'a' and public data member 'b' and three public member functions get_ab ( ), get_ a (Void), show_a (void). Derive a class 'D' from the class 'B', 'D' should contain one private data member 'C' and two member functions Mul (void) and Display (void). Define a main program in which create an object for the class and test all the four member functions.
14) Generation of uniform random numbers using virtual functions.
15) Fitting of distributions _ Binomial , Poisson and Negative binomial based on relation between mean and variance.
16) Solution to simultaneous equations by Gauss - Siedal method.

REFERENCES


1. Balagurusamy, E.(1995) : Object – oriented Programming with C++, Tata Mc Graw Hill
2. K. R. Venugopal and others (2005) : Mastering C++, Tata Mc Graw Hill
3. Strousstroup, B.(1991) : The C++ Programming Language, 2nd edition, Addison-Wesley.

M.Sc.(Applied Statistics) Semester I
**STAS1-VI :** Paper VI - Practical (LA, LM, DT, ET, ST)

# PRACTICALS IN LINEAR ALGEBRA, LINEAR MODELS, DISTRIBUTION THEORY, ESTIMATION AND SAMPLING

## LINEAR ALGEBRA

1. Inverse of a matrix by partition method.
2. Solutions of linear equations by sweep-out method.
3. Computation of Moore-Penrose inverse by Penrose method.
4. Computation of Generalized inverse of a matrix.
5. Formation of characteristic equation by using traces of successive powers.
6. Spectral decomposition of a square matrix of third order.

## LINEAR MODELS

1. Fitting of a simple linear regression model - Computation of Pure error and lack of fit.
2. Fitting of Multiple Regression models with Two and Three Independent variables. and testing of regression parameters
3. Computation and Testing of Multiple Correlation coefficient.
4. Computation and Testing of Partial Correlation Coefficients.

## DISTRIBUTION THEORY AND ESTIMATION

1. Fitting of an appropriate discrete distribution
    (i) Binomial
    (ii) Poisson
    (iii) Negative Binomial
2. Fitting of Normal Distribution
3. Fitting of
    (i) Cauchy Distribution
    (ii) Exponential Distribution
    (iii) Pareto Distribution
4. Method of MLE (Scoring Method)

## SAMPLING THEORY

1. PPS sampling with and without replacements.
2. Ratio estimators in SRS , comparison with SRS
3. Separate and combined ratio estimators, Comparison.
4. Regression estimators in SRS, Comparison with SRS and Ratio estimators
5. Separate and combined Regression estimators, Comparison.
6. Cluster sampling with equal cluster sizes.
7. Sub sampling (Two–stage sampling) with equal first stage units.

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**M.Sc. APPLIED STATISTICS**
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**WITH EFFECT FROM 2016 – 2017**

**SEMESTER II**

| Paper | Sub. Code | Paper Title | Instruction Hrs/ Week | Duration of Exam (in Hrs) | Max. Marks | IA and Assign. | Credits |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| I | STAS2-I | Statistical Inference (SI) | 4 | 3 | 80 | 20 | 4 |
| II | STAS2-II | Applied Regression Analysis (ARA) | 4 | 3 | 80 | 20 | 4 |
| III | STAS2-III | Multivariate Data Analysis (MDA) | 4 | 3 | 80 | 20 | 4 |
| IV | STAS2-IV | Design of Experiments (DOE) | 4 | 3 | 80 | 20 | 4 |
| **PRACTICALS** | | | | | | | |
| V | STAS2-V | Statistical Inference and Applied Regression Analysis (SI, ARA) | 8 | 3 | 100 | *** | 4 |
| VI | STAS2-VI | Multivariate Data Analysis and Design of Experiments (MDA, DOE) | 8 | 3 | 100 | *** | 4 |
| **Total** | | | 32 | *** | 520 | 80 | 24 |
| **Semester Total** | | | | | 600 | | |

M.Sc. (Applied Statistics) Semester II

**STAS2 – I :** Paper I - Statistical Inference (SI)

UNIT – I

Concepts of Hypothesis, Types of errors, Statistical test, critical region, test functions, randomized and non–randomized tests. Concepts of MP and UMP tests, Neymann – Pearson lemma and its applications to one parameter exponential family of distributions.

UNIT – II

Concepts of unbiased and consistent tests. Likelihood Ratio Criterion with simple applications (including homogeneity of variances). Statements of asymptotic properties of LR test. Confidence Intervals (based on fixed sample size and distributions for the parameters of Normal, exponential, Binomial, Poisson distributions). Relationship between confidence intervals and hypothesis testing. The concept of robustness in testing.

UNIT – III

Concepts of non – parametric estimation. Non- parametric methods for one-sample problems based on Run test and Kolmogorov – Smirnov test. Wilcoxon Signed rank test for one sample and paired samples. Two sample problems based on Wilcoxon Mann Whitney test. Kolmogorov test (expectation and variances of above test statistics except for Kolmogorov – Smirnov test). Statements about their exact and asymptotic distributions, Wald Wolfowitz Runs test and Normal scores test. Kendall's Tau, Ansari – Bradley test for two-sample dispersion, Kruskal – Wallis test for one – way layout. (k- samples). Friedman test for two-way layout (randomized block).

UNIT – IV

Notions of sequential vs. fixed sample size techniques. Wald's sequential probability Ratio Test (SPRT) for testing Simple null Hypothesis vs. simple alternative. Termination property of SPRT. SPRT procedures for Binomial, Poisson, Normal and exponential distributions and associated OC and ASN functions. Statement of optimality properties of SPRT.

**REFERENCES**


1. Rohatgi, V.K.: An Introduction to Probability Theory and Mathematical Statistics (Wiley Eastern)
2. Gibbons : Non Parametric Statistical Inference,(Tata Mc Graw Hill)
3. Myles Hooander and Douglas A. Wolfe – Non parametric Statistical methods (John Wiley and sons)
4. Wald,A. : Sequential Analysis (Dover Publications)
5. Milton and Arnold – Introduction to probability and Statistics ($4^{th}$ Edition)- TMH publication.
6. Lehman, E. L. : Testing of hypothesis, John Wiey
7. Goon, Gupta and Das Gupta : Outlines of Statistics, Vol. II, World Press.


**ADDITIONAL REFERENCES**


1. C.R. Rao – Linear Statistical Inference (John Wiley)
2. W.J. Conovar – Practical Non parametric Statistics (John Wiley)

M.Sc (Applied Statistics) Semester II

**STAS2 – II :** Paper II - Applied Regression Analysis (ARA)

## UNIT – I

Review of the general regression situation, extra sum of squares principle, orthogonal columns in the X – matrix, partial and sequential F-tests. Bias in regression estimates. Weighted least squares. Introduction to examination of residuals, overall plot, time sequence plot, plot against $Y_i$, predictor variables $X_{ij}$ .Correlations and serial correlations among the residuals, Durbin Watson Test. Concept of outliers, Detecting of outliers, standardized residuals. Testing of outliers in linear models.

## UNIT – II

Introduction of selecting the best regression equation, all possible regressions: backward, stepwise regression procedures. Variations on these methods. Stagewise regression procedures. Polynomial regression –use of orthogonal Polynomials. Ridge regression: Introduction, basic form of ridge regression, ridge regression on a selection procedure.

Robust regression: Introduction, Least absolute deviation regression( $L_1$-regression),M-Estimation Procedure, Least Median squares regression, ranked residuals regression(RREG).

## UNIT – III

Logistic regression model – Introduction, Fitting the Logistic regression model, testing for the significance of the coefficients, Introduction to multiple Logistic regression, the multiple Logistic regression models, fitting the multiple logistic regression model, testing for the significance of the model.

Interpretation of the fitted Logistic regression model – Introduction, Dichotomous independent variable. Probit Analysis: Introduction, Analysis of Biological data, sigmoid curve, fitting a Probit Regression line through least squares method.

## UNIT – IV

Non-linear regression – Introduction to non-linear regression model, some commonly used families of non-linear regression functions, statistical assumptions and inferences for non-linear regression, linearizable models, determining the Least squares estimates, The Gauss – Newton method, ML estimation, (D and S), Statements of asymptotic properties, Non–linear growth models – Types of models – the Logistic model, the Gompertz model.

REFERENCES


1. Draper and Smith: Applied Regression Analysis- John Wiley
2. Dennis Cook. R and Sanford Weisberg (1999) Applied Regression Including Computing and Graphics –John Wiley
3. Galton: Applied Regression Analysis
4. Regression Analysis: Concepts and Applications, Franklin A. Graybill and Hariharan K. Iyer
5. Applied Regression Analysis, linear models and related methods: John Fox
6. Non–linear Regression Analysis and its Applications: Douglas M. Bates and Donald G. Watts
7. Applied Logistic Regression: David W. Hosme and Stanley Lemeshow.
8. Linear Models for unbalanced Data: Shayler Searle
9. Residuals and Influence in Regression: R. Dennis Cook and Sanford Weisberg
10. Log–linear models and Logistic Regression: Ronald Christensen.

M.Sc (Applied Statistics) Semester II

**STAS2 – III :** Paper III - Multivariate Data Analysis (MDA)

## UNIT – I

Motivation to take up multivariate data analysis; concept of random vector, its expectation, and variance-covariance matrix, marginal and joint distributions, stochastic independence of random vectors, conditional distributions. Multinomial Distribution, Multivariate normal distributions marginal and conditional distributions. Sample mean vectors and its distribution. Maximum likelihood estimates of parameters. Sample dispersion matrix, statement of Wishart distribution and its simple properties.

## UNIT – II

Hotelling's $T^2$ and Mahalanobis $D^2$ statistics, null distribution of Hotellings' $T^2$, wilks $\lambda$ criterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between K ($\geq$2), multivariate normal populations based on LDF and Mahalanobis $D^2$.

## UNIT - III

Path analysis and computation of path coefficients, introduction to multidimensional scaling. Classical solution: some theoretical results, similarities, metric and non-metric scaling methods. Concepts of analysis of categorical data.

## UNIT – IV

Principal component analysis, factor analysis and simple factor model (brief mention of multi-factor model). Canonical variables and canonical correlations, Introduction to cluster analysis: similarities and dissimilarities, Hierarchical clustering: Single and Complete linkage method.

## REFERENCES


1. Johnson, R.A, and Dean W. Wichern: Applied Multivariate Statistical Analysis.
2. Morrison, D: An Introduction to Multivariate Analysis.
3. Seber : Multivariate Observations
4. Anderson: An Introduction to Multivariate Analysis.
5. Bishop: Analysis of Categorical data.

M.Sc. (Applied Statistics) Semester II

**STAS2 – IV :** Paper IV - Design of Experiments (DOE)

## UNIT – I

Analysis of co-variance: one–way and two–way classifications. Estimation of main effects, interactions and analysis of $2^k$ factorial experiment in general with particular reference to k = 2,3 and 4 and $3^2$ factorial experiments. Multiple comparisons, Fisher Least Significance Difference (L.S.D) test and Duncan's Multiple range test (DMRT).

## UNIT – II

Total and partial confounding in case of $2^3$, $2^4$ and $3^2$ factorial designs. Concept of Balanced partial confounding. Fractional replications of factorial designs – one-half replication of $2^3$ & $2^4$ design, one-quarter replication of $2^5$ and $2^6$ designs. Resolution of a design, Split – plot design.

## UNIT – III

Balanced incomplete block design (BIBD) – parametric relations, intra-block analysis, recovery of inter-block information. Partially balanced incomplete block design with two associate classes PBIBD (2) – Parametric relations, intra block analysis. Simple lattice design and Youden-square design.

## UNIT – IV

Concept of Response surface methodology (RSM), the method of steepest ascent. Response surface designs. Design for fitting first – order and second – order models. Variance of estimated response. Second order rotatable designs (SORD), Central composite designs(CCD): Role of CCD as an alternative to $3^k$ design, Notatability of CCD.

## REFERENCES


1. Das, M.N. and Giri,N.: Design and Analysis of Experiments, Wiley Eastern.
2. Montogomery, D.C. : Design and Analysis of Experiments, John Wiley.
3. Draper and Smith : Applied Regression Analysis, John Wiley.
4. Parimal Mukhopadhyay : Applied Statistics, New Central Book Agency.


## ADDITIONAL REFERENCES


1. Cochran and Cox : Experimental designs, John Wiley.
2. Kempthrone : Desing and Analysis of Experiments, John Wiley.
3. Kapoor and Gupta : Applied Statistics, Sultan Chand.
4. Alok Dey : Theory of Block Desings, Wiley Eastern.

M.Sc. (Applied Statistics) Semester II
**STAS2 – V :** Paper V Practical (SI and ARA)

# PRACTICALS IN STATISTICAL INFERENCE AND APPLIED REGRESSION ANALYSIS

## STATISTICAL INFERENCE

1. Type I and Type II errors
2. MP tests
3. UMP tests
4. L.R. Tests
5. Wilcoxon Signed rank test
6. Wilcoxon Mann-Whitney test
7. Kolmogorov – Smirnov one sample, two sample tests
8. Ansari – Bradley test for two sample dispersion
9. Krusakal Walli's test for one way layout
10. Friedman test for two way layout
11. Normal Scores test
12. Kendall's Tau
13. SPRT procedures for
    - (i) Binomial
    - (ii) Poisson
    - (iii) Normal and computation of their OC function.

## APPLIED REGRESSION ANALYSIS

1. Testing of general linear hypothesis.
2. Computation of residuals and their plots.
3. Computation and testing of Serial Correlation.
4. Computation of Partial F for two variable regression model.
5. Computation of all possible regression for three variables using $R^2$.
6. Probit and Logit analysis

M.Sc.(Applied Statistics) Semester II
**STAS2 – VI :** Paper VI Practical (MDA and DOE)

# PRACTICALS IN MULTIVARIATE DATA ANALYSIS AND DESIGN OF EXPERIMENTS

## MULTIVARIATE DATA ANALYSIS

1. MLE of parameters of multivariate normal distribution.
2. Computation of Hotellings $T^2$ and Mahalanobis $D^2$.
3. Computation Path coefficients.
4. Classification between two normal populations by discriminant analysis.
5. Computation of Principle Components.
6. Computation of canonical correlations
7. Estimating the factor loading in single factor model.
8. Computation of single linkage method.
9. Single linkage dendogram for dissimilarity matrix.

## DESIGN OF EXPERIMENTS

1. Analysis of $2^3$ and $2^4$ factorial experiments.
2. Analysis of $3^2$ factorial experiment.
3. Analysis of Total and partial confounding of $2^3$ factorial design.
4. Analysis of one-half fraction of $2^4$ design and one-quarter fraction of $2^5$ design.
5. Analysis of Split-plot Design
6. Intra-block analysis of BIBD
7. Intra-block analysis of PBIBD(2)
8. Analysis of Youden-square design
9. Analysis of Simple Lattice design

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**SEMESTER III**

| Paper | Sub. Code | Paper Title | Instruction Hrs/ Week | Duration of Exam (in Hrs) | Max. Marks | IA and Assign. | Credits |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| I | STAS3-I | Operations Research–I (OR-I) | 4 | 3 | 80 | 20 | 4 |
| II | STAS3-II | Reliability Theory (RT) | 4 | 3 | 80 | 20 | 4 |
| III | STAS3-III | Elective - I | 4 | 3 | 80 | 20 | 4 |
| IV | STAS3-IV | Elective - II | 4 | 3 | 80 | 20 | 4 |
| **PRACTICALS** | | | | | | | |
| V | STAS3-V | Operations Research–I and Reliability Theory (OR-I, RT) | 8 | 3 | 100 | *** | 4 |
| VI | STAS3-VI | Elective – I and Elective - II | 8 | 3 | 100 | *** | 4 |
| **Total** | | | 32 | *** | 520 | 80 | 24 |
| **Semester Total** | | | | | 600 | | |

Electives to be offered in Semester III **:**

1. Forecasting Models (FM)
2. Statistical Process and Quality Control (SPQC)
3. Actuarial Statistics (AS)

M.Sc. (Applied Statistics) Semester III

**STAS3 - I :** Paper – I : Operations Research–I (OR-I)

Unit–I

Definition and scope of OR: Phases in O.R.; Models and their solutions; decision making under uncertainty and risk.

Duality and complementary slackness theorem, primal dual relation; dual simplex algorithm;

Sensitivity Analysis: Introduction, definition of sensitivity analysis; discrete changes in requirement and cost vectors. Parametric Programming: Introduction, parameterization of cost and requirement vectors.

Unit–II

Queuing Theory: Introduction, essential features of Queuing system, Operating characteristics of Queuing system (transient and steady states).Queue length, General relationships among characteristics. Probability distribution in queuing systems, distribution of Arrival and interarrival. Distribution of death (departure) process, service time. Classification of Queuing models and solution of Queuing models; M/M/1:∞/FIFO and M/M/1:N/FIFO

Sequencing and scheduling Problems: 2 machine n-job and 3 machine n-job problems with identical machine sequence for all jobs; 2-job n-machine problem with different machine problem with different routings.

Unit–III

Inventory: Analytical structure of inventory problems; ABC analysis; EOQ problem with and without shortages with (a) production is instantaneous (b) Finite constant rate (c) shortages permitted random models where the demand follows uniform distribution. Multi-item inventory subject to constraints.

Networks: Basic concepts constraints in networks, construction of networks. Time calculation in Networks. PERT, CPM, Network problems.

Unit–IV

Integer Programming Problem: Gomory's cutting plane algorithm for pure and mixed IPP; Branch and bound Technique.

Stochastic Programming problem; analysis of chance constrained linear programming under zero order, non randomised decision rule, deterministic equivalents of chance constraints with reference to Normal and Cauchy distributions.

**REFERENCES**


1. Kantiswarup; Gupta P.K. and Singh,M.N.(1985):Operations Research; Sultan Chand
2. Sharma,S.D.: Operations Research
3. Taha, H.A.(1982): Operations Research: An Introduction; MacMillan
4. Gillet.: Introduction to O. R.


**ADDITIONAL REFERENCES**


1. Hillier F.S. and Leiberman,G.J.(1962) : Introduction to Operations Research; Holdon Day.
2. Philips, D.T.,Ravindran,A. and Solbeg,J.(2000) : Operations Research principles and practice.

M.Sc. (Applied Statistics) Semester III
**STAS3 - II :** Paper II - Reliability Theory (RT)

## Unit–I

Coherent Systems: Reliability concepts – Systems of components. Series and parallel systems – Coherent structures and their representation in terms of paths and cuts, Modular decomposition.

## Unit–II

Reliability of coherent systems – Reliability of Independent components, association of random variables, bounds on systems reliability and improved bounds on system reliability under modular decomposition.

## Unit–III

Life Distribution: Survival function – Notion of aging IFR, DFR, DFRA, NBU and NBUE classes, Exponential distributions and its no-ageing property, ageing properties of other common life distribution, closures under formation of coherent structures, convolutions and mixtures of theses cases.

## Unit–IV

Maintenance and replacement policies, relevant renewal theory, availability theory, maintenance through spares and repair.

Reliability estimation: Estimation of two and three parameter Gamma, Weibull and log normal distributions.

## REFERENCES


1. Barlow, R.E. and Proschen, F. (1975): Statistical Theory of Reliability and life testing. Halt, Reinhart and Winston Inc.

   Chapter I – Section 1 to 4
   II – Section 1 to 4
   III – Section 1,2,4 and 5
   IV – Section 1 to 4
   VI – Section 1 to 3
   VII – Section 1 to 3, Section 4.1,4.2


## ADDITIONAL REFERENCES


1. Barlow and Proschen (1965): Mathematical Theory of Reliability, John Wiley
2. Balaguru Swamy – Reliability Engineering
3. L.J. Bain: Statistical analysis of Reliability and like testing Marcel Decker.
4. Sinha, S.K., and Kale, S.K., (1980): Life testing and Reliability estimation, Wiley Eastern.

M.Sc.(Applied Statistics) Semester III

**STAS3 - III :** Elective I/II : Forecasting Models (FM)

Unit–I

Forecasting: The role of forecasting in decision-making, forecasting techniques. Smoothing Techniques: Simple Moving Averages, exponential smoothing and Winter's linear and seasonal exponential smoothing.

Stationary stochastic processes, Autocovariance and Autocorrelation functions and their estimation. Standard error of autocorrelation estimates. Bartlett's approximation (without proof). Periodgram, power spectrum and spectral density functions. Simple examples of autocorrelation and spectral density functions. Link between sample spectrum and auto-correlation function.

Unit–II

Linear Stationary Models: Two equivalent forms for the general linear process. Autocovariance generating function and spectrum. Stationarity and invertibility conditions for a linear process. Autoregressive and moving average processes, autocorrelation function (ACF), partial autocorrelation function (PACF). Spectrum for AR processes up to 2. Moving average process, stationarity and invertibility conditions. ACF and PACF for M.A.(q) spectrum for M.A. processes up to order 2, Duality between autoregressive and moving average processes. Mixed AR and MA (ARMA) process. Stationarity and invertibility properties, ACF and spectrum of mixed processes. The ARMA(1,1) process and its properties.

Unit–III

Linear Non-Stationary Models–Autoregressive integrated and moving average (ARIMA) processes. The three explicit forms for the ARIMA models viz., difference equation, random shock and inverted forms.

Model Identification: Stages in the identification procedures, use of autocorrelation and partial auto–correlation functions in identification. Standard errors for estimated auto correlations and partial autocorrelations. Initial estimates of parameters of MA, AR and ARMA processes and residual variance.

Model estimation: Least squares and Maximum likelihood estimation and interval estimation of parameters.

Unit–IV

Model diagnostic checking–Checking the stochastic model. Diagnostic checks applied to residuals.

Forecasting-minimum: Mean square error forecasts and their properties, derivation of the minimum mean square error forecasts, calculating and updating forecasts, probability limits of the forecasts at any lead time.

REFERENCES


1) Weel Wright, S.C. and Makridakis,S. (1973) : Forecasting methods for Management, John–Wiley & sons, New York.
2) Box, G.E.P. and Jankins,G.M.(1970) : Time series Analysis (Forecasting and control), Holden day publication.


ADDITIONAL REFERENCES


1. Anderson, T.W.(1971) : The statistical analysis of Time series, John Wiley, New York.
2. Brockwell,P.J. and Davis, R.A. : Time Series : Theory and methods(Second Edition), Springer-Verlag.

M.Sc. (Applied Statistics) Semester III

**STAS3 - IV :** Elective I/II : Statistical Process and Quality Control (SPQC)

## Unit–I

Basic concept of process monitoring – Basic principles, Choice of control limits, sample size and sampling frequency, rational subgroups, analysis of patterns on control charts, magnificent seven, nonmanufacturing applications of Statistical process control, Process capability and Process optimisation.

General theory and review of control charts for variable data and attributes : O.C. and A.R.L. functions of control charts, modified control charts for variables and Acceptance control charts for attributes, control by gauging.

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## Unit–II

Moving Average and exponentially weighted moving average charts, Cu-sum charts using V-Masks and decision intervals, Economic design of X bar chart. Concept of control chart for non-normal distributions, concept of Nonparametric control charts.

## Unit–III

Acceptance sampling plans for attribute inspection, single, double and sequential sampling plans and their properties; Rectifying sampling plans for attributes, AOQ, AOQL, designing of R.S.P. for specified AOQL and LTPD. Plans for inspection by variables for one–sided and two–sided specifications; Dodges Continuous sampling Plan–I and its properties modifications over CSP–I.

## Unit–IV

Process Capability Analysis: Capability indices Cp, Cpk and Cpm, estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Multivariate quality control, use of control ellipsoid and of utility functions. Concept of TQM, Six sigma.

## REFERENCES


1) Montgomery, D.C.(1985) : Introduction to Statistical Quality Control, Wiley
2) Wetherill, G.B. (1977): Sampling Inspection and Quality Control, Halsted Press.
3) Cowden, D. J. (1960) : Statistical Methods in Quality Control, Asia Publishing House.


## ADDITIONAL REFERENCES


1. Ott,E.R. (1975) : Process Quality Control, McGraw Hill
2. Phadke, M.S. (1989): Quality Engineering through Robust Design, Prentice Hall.
3. Wetherill, G.B., and Brown, D.W: Statistical Process Control: Theory and Practice, Chapman and Hall.

M.Sc. (Applied Statistics) Semester III

**STAS3 - IV :** Elective I/II : Actuarial Science (AS)

## Unit–I

Economics of Insurance - Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force of mortality.

Life table and its relation with survival function examples, assumptions of fractional ages, some analytical laws of mortality, select and ultimate tables**.**

## Unit–II

Types of Life insurance products – Term insurance, Whole-life insurance, Endowment insurance and Annuities. Measurement of risk in life insurance and fundamental principles underlying rate-making. Elements of compound interest – Nominal and effective rates of interest, discount, accumulation factor and continuous compounding.

## Unit–III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions, evaluation for special mortality laws.

Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

Distribution of aggregate claims, compound Poisson distribution and its applications.

## Unit–IV

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, and 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 apportionable or discounted continuous basis reserves at fractional durations.

## REFERENCES


1. N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones and C. J. Nesbitt (1986): Actuarial Mathematics, Society of Actuaries, Ithaca, Illinois, USA .
2. S. S. Huebner and J. R. Kenneth Black (1976) : Life Insurance, Ninth Ed., PHI Pvt. Ltd.
3. S. P. Dixit, C. S. Modi and R. V. Joshi (2000) : Mathematical Basis of Life Insurance, Indian Institute of India.
4. Neill, A.(1977): Life contingencies, Heinemann.
5. Spurgeon E.T.(1972): Life contingencies, Cambridge University Press
6. Benjamin, B and Pollard, J. H. (1980): Analysis of Mortality and other Actuarial Statistics.
7. Federation of Insurance Institutes study courses: mathematical basis of Life Assurance F.I.21 (Published by Federation if Insurance Institutes, Bombay).


M.Sc. (Applied Statistics) Semester III

**STAS3 - V :** Paper V – Practical (OR-I and RT)

Practical in Operations Research–I and Reliability Theory

### Operations Research–I

1. Solving an LPP by Dual Simplex Method
2. Solving an LPP by Revised Simplex
3. Sensitivity Analysis for cost and requirement vectors.
4. Parametric Programming for cost and requirement vectors.
5. Sequencing problem with 2 jobs n machine problem by graphical method.
6. Evaluation of project time through CPM and PERT
7. Time cost Analysis for CPM and PERT
8. Integer Programming Problem- Gomery's cutting plane method.

### Reliability Theory

1. Finding Minimal path sets and Minimal cut sets and their representations.
2. Computation of System reliability – parallel, Series and k out of n system.
3. Computations of reliability of Structures when components are independent.
4. Computation of estimated reliability and hazard rates.
5. Computation of bounds on systems reliability.
6. Graphing the reliability function of the systems when the life times of components are exponentially distributed.

M.Sc. (Applied Statistics) Semester III

**STAS3 - VI :** Paper VI – Practical (Elective I and Elective II)

## Practical in Forecasting Models and Statistical Process and Quality Control

### Forecasting Models

1. Moving Averages and exponential smoothing.
2. Generation of Time series by means of simple time series models.
3. Sample and theoretical correlograms.
4. Periodogram analysis.
5. Writing the models in B notation and stationarity and invertability of the models.
6. Classification of ARIMA models and computation of weights.
7. Identification AR, MA and ARMA models.
8. Estimation of parameters in AR, MA and ARMA models.
9. Computation of forecasts, updating and probability limits for forecasts.

### Statistical Process and Quality Control

1. Construction of $\overline{X}$ , R and $\sigma$ - charts and OC curves for $\overline{X}$ and R charts
2. Construction of p – chart (with constant and variable sample size) – OC curve for constant sample size
3. Construction of C–chart and U–chart and OC curve for C–Chart
4. Construction of Simple and Exponentially weighted moving average control chart and simple moving range control chart.
5. Construction of CUSUM chart using tabular approach.
6. Construction of CUSUM charts V – Mark and ARL curves
7. Designing Single Sampling Plans for specified $p_1$,$p_2$,$\alpha$ and $\beta$
8. OC, ASN Curves for double sampling plans – designing for specified $p_1$,$p_2$,$\alpha$ and $\beta$
9. Construction of AOQ and AFI curves for CSP–I
10. Computation of process capability indices

## PRACTICAL ON ACTURIAL SCIENCE

1. Computation of values of utility function.
2. Computation of various components of life tables.
3. Computation of compound interest (nominal and effective rate of interests).
4. Annuities and annuity dues.
5. Computation of premium for Term insurance and Whole life insurance.
6. Computation of premium for Endowment insurance.
7. Construction of multiple decrement table for deterministic survival group.
8. Determination of distribution function, survival function and force of mortality.
9. Construction of multiple decrement table for random survivorship group.
10. Construction of select, ultimate and aggregate mortality.
11. Calculation of p.d.f. and distribution function of aggregate claims.
12. Computation of discrete and continuous net premiums.
13. Office premium a.
14. Assurances payable at the moment of death.

**DEPARTMENT OF STATISTICS**
UNIVERSITY COLLEGE OF SCIENCE
OSMANIA UNIVERSITY, HYDERABAD – 500 007

**M.Sc. APPLIED STATISTICS**
**CBCS** - SCHEME OF INSTRUCTION AND EXAMINATION
**WITH EFFECT FROM 2017 – 2018**

**SEMESTER IV**

| Paper | Sub. Code | Paper Title | Instruction Hrs/ Week | Duration of Exam (in Hrs) | Max. Marks | IA and Assign. | Credits |
|---|---|---|---|---|---|---|---|
| **THEORY** | | | | | | | |
| I | STAS4-I | Operations Research–II (OR–II) | 4 | 3 | 80 | 20 | 4 |
| II | STAS4-II | Applied Stochastic Processes (ASP) | 4 | 3 | 80 | 20 | 4 |
| III | STAS4-III | Elective - I | 4 | 3 | 80 | 20 | 4 |
| IV | STAS4-IV | Inter Disciplinary Paper (IDC) | 4 | 3 | 80 | 20 | 4 |
| **PRACTICALS** | | | | | | | |
| V | STAS4-V | Operations Research – II, Applied Stochastic Processes and Elective I (OR–II, ASP, Elect. I) | 8 | 3 | 100 | *** | 4 |
| VI | STAS4-VI | Practical with Statistical Packages | 8 | 3 | 100 | *** | 4 |
| **Total** | | | 32 | *** | 520 | 80 | 24 |
| **Semester Total** | | | | | 600 | | |

**Note :** Any ONE of the following papers can be taken as Elective Paper

1. Artificial Neural Networks (ANN)
2. Statistical Pattern Recognition (SPR
3. Inter Disciplinary Course (IDC) :
   **Basic Statistics**
   **(Only for non-Statistics students)**

M.Sc. (Applied Statistics) Semester IV

**STAS4 – I :** Paper I - Operations Research – II (OR – II)

## Unit–I

Non-linear Programming problem – Formulation Generalised Lagrange multiplier technique, Kuhn-Tucker necessary and sufficient conditions for optimality of an NLPP, Wolfe's and Beale's Algorithms for solving QPP. Separate Programming Problem; Piecewise linearization method.

## Unit–II

Dynamic Programming, Principle of optimality, solution of LPP by Dynamic Programming technique, Knapsack problem by Dynamic Programming Technique. General goal Programming model and formulation of its objective function. Solutions to linear goal programming and linear integer goal programming.

## Unit–III

Game Theory : 2 person zero sum game, pure strategies with saddle point, mixed strategies with saddle point, principles of dominance and games without saddle point.

Introduction to simulation, generation of random numbers for Uniform, Normal, Exponential, Cauchy and Poisson Distributions. Estimating the reliability of the random numbers, Simulation to Queuing and Inventory problem.

## Unit–IV

s-S policy for inventory and its derivation in the case of exponential demand; Models with variable supply and models for perishable Items.

Replacement Problems; Introduction, block and age replacement policies, replacement of items with long life. Machine interference problems.

## REFERENCES


1. Taha, H.A.(1982): Operations Research : An Introduction; McMillan
2. Kantiswarup;Gupta P.K. and Singh,M.N.(1985) : Operations Research; Sultan Chand.
3. Sharma,S.D.: Operations Research.
4. U. N. Bhat: Introduction to Applied Stochastic Process.


## ADDITIONAL REFERENCES


1. Hillier F.S. and Leiberman,G.J.(1962) : Introduction to Operations Research; Holdon Day
2. Philips, D.T.,Ravindran,A. and Solberg,J.(2000) : Operations Research principles and practice.

M.Sc. (Applied Statistics) Semester IV

**STAS4 – II :** Paper II - Applied Stochastic Processes (ASP)

Unit–I

Markov Chains: Classification of states, canonical representation of transition probability matrix. Probabilities of absorption and mean times for absorption of the Markov Chain from transient states into recurrent classes. Limiting behaviour of Markov chain: Stationary distribution

Unit–II

Continuous–time Markov Processes: Kolmogorov–Feller differential equations, Poisson process and birth and death processes.

Renewal Processes: Renewal process when time is discrete and renewal process with time is continuous, with examples. Renewal function, renewal density, limiting behaviour. Statement of elementary and basic renewal theorems.

Branching Processes: Examples of natural phenomena that can be modelled as a branching process. Probability of extinction; Statement of fundamental theorem of branching processes.

Note: Emphasis is only on statements of theorems and results and their applications.

Unit–III

Stochastic Processes in Biological Sciences: Markov models in population genetics; Recovery, relapse and death due to disease; cell survival after irradiation; compartmental analysis.

Stochastic Processes in communication and information systems: Markov models in storage requirements for unpacked messages; buffer behaviour for batch arrivals; loop transmission systems; a probabilistic model for hierarchical message transfer.

Stochastic Processes in traffic–flow theory; some traffic flow problems; pedestrian traffic on a side–walk; free–way traffic; parking lot traffic; intersection traffic; left–turning traffic; pedestrian delay; headway distribution

Unit–IV

Stochastic Processes in social and behavioural sciences; Markov chain models in the study of social mobility; industrial mobility of labour; educational advancement; labour force planning and management; diffusion of information.

Stochastic Processes in Business Management: Markov models in marketing and accounting; consumer behaviour; selecting a port–folio of credit–risks; term structure; human resource management; income determination under uncertainty.

**REFERENCE**

1. Bhat, U.N., (1984): Elements of Applied Stochastic Processes, John Wiley

**ADDITIONAL REFERENCE**

1. Ross, S. (1996): Stochastic Processes, Second Edition, John Wiley.
2. J. Medhi: Stochastic Processes.

M.Sc.(Applied Statistics) Semester IV

**STAS4 – III :** Elective IA - Statistical Pattern Recognition (SPR)

## Unit–I

Basic concepts of pattern recognition. Fundamental problems in pattern recognition. Linear classifiers (Statistical approximation), Linear discriminant function for minimum squared error, L.D.F. for binary outputs; perception learning algorithm.

## Unit–II

Nearest neighbour decision rules: description convergence, finite sample considerations, use of branch and bound methods.

## Unit–III

Probability of errors: Two classes, Normal distribution, equal covariance matrix assumptions, Chernoff bounds and Bhattacharya distance, estimation of probability of error. Introduction to Hidden Markov Models (H.M.M.) and its applications.

## Unit–IV

Feature selection and extraction: Interclass distance measures, discirmanant analysis, Probabilistic distance measures, Principal Components.

## REFERENCES


1) R.O. Duda & H.E. Hart(1978): Pattern Recognition and scene analysis, Wiley
2) J.T. Ton and R.C. Gonzalez (1974) : Pattern Recognition Principles, Addison Wesley Publishing Company
3) G.J. McLactilan (1992): Discriminant Analysis and Statistical Pattern Recognition, Wiley
4) B.D. Ripley (1996) : Pattern Recognition & Neural Networks, Cambridge University Press.
5) Duda, Hast & Strok: Pattern Recognition.

M.Sc.(Applied Statistics) Semester IV

**STAS4 – IV :** Elective IB – Artificial Neural Networks (ANN)

Unit – I

Biological Neuron, Biological and Artificial Neuron Models, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN. Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN, Learning Strategy (Supervised, Unsupervised, Reinforcement) and Learning Rules.

Unit – II

Gathering and partitioning of data for ANN and its pre and post processing. Single Layer Feed Forward Neural Networks: Perceptron Models, Hebbian Learning and Gradient Descent Learning. Limitations and applications of the Perceptron Model. Multilayer Feed Forward Neural Networks: Generalized Delta Rule, Back propagation (BP) Training Algorithm, Learning rate, Momentum and Conjugate Gradient Learning, Difficulties and Improvements. Bias and Variance. Under- Fitting and Over-Fitting.

Unit – III

Radial Basis Function Networks: Introduction, Algorithms and Applications. . Approximation properties of RBF. Self Organizing Maps: Fundamentals, Algorithms and Applications.

Unit – IV

Applications of ANN in classification, clustering, regression, time series forecasting, variable selection and dimensionality reduction.

## REFERENCES


1) Bishop, C. (1995). *Neural Networks for Pattern Recognition.* Oxford: University Press. Extremely well-written but requires careful reading, putting neural networks firmly into a statistical context.
2) Haykin, S. (1994). *Neural Networks: A Comprehensive Foundation.* New York: Macmillan Publishing. A comprehensive book and contains a great deal of background theory.
3) Ripley, B.D. (1996). *Pattern Recognition and Neural Networks.* Cambridge University Press. A very good advanced discussion of neural networks, firmly putting them in the wider context of statistical modeling.
4) Neural Networks Chapter in www.statsoft.com


## ADDITIONAL REFERENCES


1) Carling, A. (1992). *Introducing Neural Networks.* Wilmslow, UK: Sigma Press.
2) Fausett, L. (1994). *Fundamentals of Neural Networks.* New York: Prentice Hall.
3) Patterson, D. (1996). *Artificial Neural Networks.* Singapore: Prentice Hall.
4) Kishan Mehrotra, Chilukuri K. Mohan and Sanjay Ranka(1996). Elements of Artificial Neural Networks:The MIT Press.

M.Sc.(Applied Statistics) Semester IV

**STAS4 – V :** Paper V Practical (OR-II, ASP, Elect. I)

Practical in Operations Research–II, Applied Stochastic Processes, Statistical Pattern Recognition and Artificial Neural Networks

## Operations Research–II

1. Wolfe and Beale's methods for QPP
2. Separable Programming problem
3. Dynamic Programming Problem
4. Goal Programming Problem
5. Game Theory
6. Simulation

## Applied Stochastic Processes

1. Classification of states of a Markov chain, determination of periods of states and mean recurrence times of recurrent states.
2. Computation of higher order transition probability matrix in a two–state Markov chain using spectral decomposition
3. Probabilities of absorption and mean time for absorption from each transient state into recurrent class.
4. Determination of stationary distribution(s) and evaluation of the same.

## Statistical Pattern Recognition

1. Linear Classifiers using LDF
2. Binary outputs using LDF
3. Probability of Errors – Normal distribution with equal covariance matrix
4. Hidden Markov Model
5. Feature relation using P.C.A.

## Artificial Neural Networks

1. Forward propagation
2. Backward propagation
3. Classification
4. Clustering
5. Regression
6. Time Series

Note : 1and 2 by manual computations and 3 to 6 by using Neuro Solutions/SPSS

M.Sc.(Applied Statistics) Semester IV
**STAS4 – VI :** Paper VI Practical

Practical with SPSS Package for the following topics.

1. Charts and Diagrams
2. Basic Statistics
3. Design of Experiments
4. Multivariate Analysis
5. Time Series Analysis
6. Parametric tests
7. Non–Parametric tests
8. Operations Research (TORA Package)
9. Statistical Quality Control
10. Regression Analysis

M.Sc. Semester IV

# Paper IV (Inter Disciplinary Course –I (IDC)) - Basic Statistics

## UNIT–I

Origin, Importance and growth of Statistics, Collection and tabulation of data. Frequency distribution. Graphical and Pictorial representation of data. Measures of central tendency: Mean, Median and Mode their merits and demerits with examples. Partition Values: Quartiles, Deciles and percentiles and examples.

Measures of dispersion: Range and standard deviation, coefficient of variation. Central and non-Central moments, coefficient of Skewness and Kurtosis, Examples.

## Unit II

Review of permutations and combinations. Deterministic and random experiment, Sample space, event mutually exclusive, equally likely and independent events with examples. Mathematical, Statistical and axiomatic definition of probability. Addition theorem, conditional probability and multiplication theorem of probability. Statistical independence and Bayes theorem –simple examples (all theorems without proofs and only statements).

## Unit III

Definition and sample examples of random variables and distribution function, probability mass function and probability density function. Mathematical expectation and moments-simple examples.

Discrete probability distributions: Bernoulli, Binomial, Poisson. Geometric, and Negative binomial distributions (concept, definition, statements of mean and variance only) with real life examples.

Continuous probability distributions: Uniform, Normal and Exponential distributions (concept, definition, statements of mean, variance and other properties).

Empirical bivariate distributions, Covariance, Karl Pearson coefficient, Rank Correlation, Curve fitting by least squares principle. Simple linear regression.

## Unit IV

Concept and definition of population, parameter, sample, statistic, sampling distribution and standard error.

Properties of Estimates: Unbiased ness, Consistency and Efficiency (concept and definition only), simple examples. Estimation of parameters by method of moments with Binomial, Poisson and Normal distributions.

Concept of testing Statistical hypothesis-Definition of Null and Alternative hypothesis, Critical region, Types of errors, level of Significance and Power of a Test.

Tests of significance based on Chi-Square, t and F distributions and ANOVA (One and Two way) with examples (No mathematical derivation only methodology).

**Note: This course is offered with a Minimum Strength of 15 Students**

**This Course is For Non Statistics Students Only**

References:


1. S.P.Gupta: Statistical Methods
2. B.S.Agarwal: Basic Statistics
3. Milton and Arnold – Introduction to probability and Statistics ($4^{th}$ Edition)-TMH Publication.