# VEER NARMAD SOUTH GUJARAT UNIVERSITY, SURAT

## SYLLABUS

## M. A. / M.Sc.: STATISTICS

## Effective From: 2019 – 2020

1. **Fee structure:-** As per Grant in Aid course

2. **Eligibility for Admission :**

   I A candidate must have passed the Bachelor's Degree examination in Science with English as compulsory subject.

   II A candidate who has obtained his/her B.Sc. degree with either (i) Statistics as principal subject or (ii) Mathematics as principal subject and Statistics as subsidiary subject or (iii) both Mathematics and Statistics as optional subjects will be eligible for admission to this course.

3. **Passing standard** in this course will be same as that of any other science subject.

# VEER NARMAD SOUTH GUJARAT UNIVERSITY

**University Campus, Udhna-Magdalla Road,**
**SURAT – 395 007.**

**SYLLABUS**

## M. A. / M.Sc. Statistics

**Effective From: 2019– 2020**

### ( Semester-I )

| Paper No. | Title of the paper | Marks | | | Work load / week | | Credit Points |
|---|---|---|---|---|---|---|---|
| | | Int. | Ext. | Total | L | Pr | |
| 101 | Real Analysis | 30 | 70 | 100 | 4 | - | 4 |
| 102 | Probability Theory | 30 | 70 | 100 | 4 | - | 4 |
| 103 | Univariate Distributions | 30 | 70 | 100 | 4 | 2 | 4 |
| 104 | Linear Algebra | 30 | 70 | 100 | 4 | 3 | 4 |
| 105 | Computer Programming Language - "C" | 30 | 70 | 100 | 4 | 3 | 4 |
| 106 | Practical paper-I (Practical +viva-voce)based on theory papers using MS office tools | 20+ 10 =30 | 50+ 20 =70 | 100 | 8 hrs | | 4 |
| Total | | 180 | 420 | 600 | 28 | | 24 |
| Total Work Load Per Week - | | | | | 28 hrs | | |

### ( Semester-II )

| Paper No. | Title of the paper | Marks | | | Work load / week | | Credit Points |
|---|---|---|---|---|---|---|---|
| | | Int. | Ext. | Total | L | Pr | |
| 201 | Estimation Theory | 30 | 70 | 100 | 4 | 2 | 4 |
| 202 | Multivariate Analysis | 30 | 70 | 100 | 4 | 2 | 4 |
| 203 | Sampling Theory | 30 | 70 | 100 | 4 | 2 | 4 |
| 204 | Actuarial Statistics | 30 | 70 | 100 | 4 | 2 | 4 |
| 205 | Linear Models | 30 | 70 | 100 | 4 | - | 4 |
| 206 | Practical Paper- II (Practical +viva-voce) based on theory papers using MS office tools | 20+ 10 =30 | 50+ 20 =70 | 100 | 8 hrs | | 4 |
| Total | | 180 | 420 | 600 | 28 | | 24 |
| Total Work Load Per Week - | | | | | 28 hrs | | |

# Effective From: 2020 -2021

## (Semester-III)

| Paper No. | Title of the paper | Marks | | | Work load / week | | Credit Points |
|---|---|---|---|---|---|---|---|
| | | Int. | Ext. | Total | L | Pr | |
| 301 | Testing of Hypotheses | 30 | 70 | 100 | 4 | 2 | 4 |
| 302 | Econometrics | 30 | 70 | 100 | 4 | 2 | 4 |
| 303 | Operations Research -I | 30 | 70 | 100 | 4 | 1 | 4 |
| 304 | Introduction to Statistical Softwares | 30 | 70 | 100 | 4 | 1 | 4 |
| 3051<br>3052<br>3053<br>3054 | Elective* (Any one)<br>Data Mining<br>Stochastic Processes<br>Mathematical Economics<br>Statistical Quality Control & Reliability | 30 | 70 | 100 | 4 | 2 | 4 |
| 306 | Practical paper- III (Practical +viva-voce) based on theory papers – using statistical software | 20+ 10 =30 | 50+ 20 =70 | 100 | 8 hrs | | 4 |
| Total | | 180 | 420 | 600 | 28 | | 24 |
| Total Work Load Per Week - | | | | | 28 hrs | | |

* Elective Paper is to be selected from the above list of papers from paper 3051 to 3054.

## (Semester-IV)

| Paper No. | Title of the paper | Marks | | | Work load / week | | Credit Points |
|---|---|---|---|---|---|---|---|
| | | Int. | Ext. | Total | L | Pr | |
| 401 | Decision Theory | 30 | 70 | 100 | 4 | 2 | 4 |
| 402 | Design of Experiments | 30 | 70 | 100 | 4 | 2 | 4 |
| 403 | Operations Research -II | 30 | 70 | 100 | 4 | 2 | 4 |
| 4041<br>4042<br>4043<br>4044 | Elective* (Any one)<br>Economic & Business Statistics<br>Official Statistics<br>Bio-Statistics & Clinical Research<br>Statistical Simulation | 30 | 70 | 100 | 4 | 2 | 4 |
| 405 | Practical paper – IV (Practical +viva-voce)based on theory papers – using statistical software | 20+ 10 =30 | 50+ 20 =70 | 100 | 8 hrs | | 4 |
| Project** | At Some industry / firm /organization | 30 | 70 | 100 | 4 hour per week per group | | 4 |
| Total | | 180 | 420 | 600 | 24+ project workload | | 24 |
| Total Work Load Per Week - | | | | | 24 hrs + project workload | | |

* Elective Paper is to be selected from the above list of papers from paper 4041 to 4044.

** To be done at some industry / firm / organization.

**GRAND TOTAL: 2400 MARKS**

# SEMESTER - I

# PAPER – 101

# REAL ANALYSIS

## UNIT I:

- **Set, Indicator factions and classes of sets**:
  - Recap of elements of set theory and Real number system.
  - Limits of sequences of sets,
  - Classes of sets like Semi-rings, rings, fields, $\sigma$ -rings, $\sigma$ -fields, Monotone classes.
  - Generated classes, Borel $\sigma$ -field of R and $R^k$ and related results.

**UNIT: II:**

- **Measurable Space:**
  - Measurable space, simple function, Measurable function, Borel measurable function and related results.
  - Almost everywhere convergence of sequence of measurable functions and related results.

**UNIT: III:**

- **Set function and Measures:**
  - Finitely additive and $\sigma$ -additive set functions,
  - Measures & its properties
  - Monotone convergence theorem,
  - Absolute continuity and singularity of measures.
  - Statements of 'Lebesgue Decomposition theorem' and the Radon – Nikodym theorem.

**UNIT: IV:**

- Integration of Simple functions and measurable function
  - Integration of Simple functions with respect to a given measure & its properties
  - Integration of measurable function with respect to a given measure.
  - Elementary properties of integral of measurable function and related results.

**UNIT: V:**

- **Caratheodory extension theorem & its Applications:**
  - Caratheodory extension theorem (statement only)
  - Construction of Lebesgue measures
  - Lebesgue- Stieltjes measures through distribution functions.

## REFERENCES


1. Ash Robert : "Real Analysis and Probability"; Academic Press.
2. Halmos P.R. : "Measure Theory"; McGraw Hill.
3. Kingman JFC and Taylor S.J. : "Introduction to Measure and Probability"; Cambridge Uni. Press.
4. Burrill C.W. : "Measure, Integration and Probability".

# PAPER – 102

# PROBABILITY THEORY

**UNIT I:**

- **Probability measure, random variable and inequalities:**
  - Probability spaces, Random variables and random vectors. Expectations. Moments.
  - Holder's inequality, Minkowski's inequality, Cauchy–Schwartz inequality, Markov's inequality, Jenson's inequality, Chebychev's inequality

**UNIT II:**

- **Distribution of a random variable and Characteristic functions:**
  - Distribution function, joint distribution function. Decomposition of a d.f. in its discrete, absolutely continuous and singular parts.
  - Weak convergence of sequences of distribution functions. The weak compactness theorem.
  - Characteristic functions and their properties.
  - Inversion theorem, Uniqueness theorem, Continuity theorem (statement only) and their properties.

**UNIT III:**

- **Stochastic Independence and Conditional Expectations:**
  - Independence of events, classes and random variables.
  - The multiplication theorem, Borel - Cantelli lemma, Borel zero-one law,
  - Sequence of independent random variables, Tail $\sigma$-field and Kolmogorov zero-one law.
  - Conditional Expectations and its properties

**UNIT IV:**

- **Convergence of sequences of random variables:**
  - Convergence almost everywhere of sequences of random variables in probability
  - Convergence of sequences of random variables in $r^{th}$ mean and
  - Convergence of sequences of random variables in probability
  - Convergence of sequences of random variables in distribution
  - Inter – relationships amongst these modes of convergence.

**UNIT V:**

- **Laws of Large Numbers and Central limit theorems:**
  - Weak law of Large numbers,
  - Kolmogorov's inequality, Kolmogorov's strong law of large numbers.
  - Central limit theorems- Liapunov's theorem. Statement of Lindbergh- Feller theorem.

## REFERENCES


1. Loeve M. : "Probability Theory".
2. Burrill C.W. : "Measure, Integration and Probability".
3. Ash Robert : "Real Analysis and Probability"; Academic Press.
4. Chang K.L.: "A Course in Probability Theory".
5. Dudley R.M. : "Real Analysis and Probability"; Wadsworth & Brooks.

# PAPER - 103

# UNIVARIATE DISTRIBUTIONS

**UNIT I:**

- Laplace, Lognormal and Cauchy distributions. Idea of truncated distributions, Truncated Poisson and Normal distributions.

**UNIT II:**

- Univariate compound distribution: Contagious distributions: Neyman type-A, Poisson-Binomial and Poisson –Negative Binomial distribution, Univariate Power series distributions.

**UNIT III:**

- Non-central distributions: Non-central chi-square, t and F distribution.

**UNIT IV:**

- Ordered statistics, their distributions and properties, distribution of Range.

## REFERENCES


1. Johnson N.L. and Kotz S.: “Distributions in Statistics”; John Wiley.
2. Fioz M.: “Probability Theory and Mathematical Statistics”; John Wiley.
3. Rohatgi V.K. : “An Introduction to Probability Theory and Mathematical Statistics”; John Wiley.
4. Jaiswal M.C. : “Statistical Distributions”; (in Gujarati), University Book Publication Board.
5. Patel J.K. et al. : “Handbook of Statistics Distributions”; Marcel Dekker.
6. Mood A.M., Graybill F. and Boes D.C. : “Introduction to the Theory of Statistics”; McGraw Hill.

# PAPER – 104

# LINEAR ALGEBRA

**UNIT I:**

- Fields, Vector Spaces, subspaces, linear dependence and independence, basis and dimension of a vector space, finite dimensional vector space, completion theorem. Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthogonal basis.

**UNIT II:**

- Symmetric, skew-symmetric, Hermitian, skew-hermitian, orthogonal, unitary and normal matrices. Laplace expansion method, Matrix polynomial, Rank of a matrix, Properties of rank of a matrix, Idempotent matrices, generalized inverses, Moore-Penrose generalized inverse.

**UNIT III:**

- Real quadratic forms, reduction and classification of quadratic forms, index and signature, properties of quadratic forms.

**UNIT IV:**

- Characteristic roots and vectors, properties of characteristic roots and vectors of a real symmetric, hermitian, skew-hermitian, orthogonal, unitary and normal matrices, Algebric and geometric multiplicity of a characteristic root.

## REFERENCES


1. Gralbill F. A.: “Matrices with Applications in Statistics”; 2nd Ed., Wadsworth.
2. Rao C.R. : “Linear Statistical Inference and its Application”; 2nd Ed., John Wiley and Sons, Inc.
3. Searle S.R.: “Matrix Algebra useful for Statistics”; John Wiley and Sons, Inc.
4. Rao C.R. and Bhimasankaram P.: “Linear Algebra”; Tata McGraw Hill Pub.Co. Ltd.


## Additional Books


1. Bellman R. : “Introduction to Matrix Analysis”; 2nd. Ed., McGraw Hill.
2. Biswas S. : “Topics in Algebra of Matrices”; Academic pub.
3. Hadley G. : “Linear Algebra”; Narosa Pub. House.
4. Halmos P.R.: “Finite Dimensional Vector Spaces”; 2nd Ed., D. Van Nostrard Co. Inc.
5. Hoffman K. and Kunze R.: “Linear Algebra”; 2nd Ed., Prentice Hall, Inc.
6. Rao C.R. and Mitra S.K.: “Generalized Inverse of Matrices and its Application”; John Wiley and Sons, Inc.

# PAPER - 105
# COMPUTER PROGRAMMING LANGUAGE – 'C'

**UNIT I:**

- Introduction
  - Algorithms and Flowchart
  - Types of Language
  - Introduction to C Language
- C Fundamentals
  - Identifiers
  - Data Types
  - Constants and Variables
  - Arrays
- Operators and Expressions
  - Arithmetic Operators
  - Unary Operators
  - Relations Operators
  - Logical Operators
  - Assignment Operators
  - Conditional Operators
  - Library Functions
  - Expressions
  - Evaluation of Expression

**UNIT II:**

- Data Input and Output
  - Single Character input and output
  - The scanf function
  - The printf function
  - Gets and Puts functions
- Control Statements
  - The While Statement
  - do-while statement
  - for statement
  - if - else statement
  - switch statement
  - break statement
  - continue statement
  - goto statement

**UNIT III:**

- Functions
  - Introduction to functions
  - Function definition
  - Accessing function
  - Passing arguments to function
  - Recursive function
- Data Files

**UNIT IV:**

- Arrays
  - Defining an array
  - Processing an array
  - Multi dimensional arrays
  - Passing array to a function
  - Arrays and Strings

- Structures and Unions
  - Defining a structure
  - Processing a structure
  - Unions

## REFERENCES


1. Karnighan B. W. and Ritchie D. M. (1978) : "C programming Language"; Prentice Hall-Gale, **ISBN:** 0131101633, **ISBN-13:** 9780131101630
2. VijayMukhi: "The C Odyssey -vol. 6: Windows"; Bpb, **ISBN:8170291682**, **ISBN-13:** 9788170291688
3. Stephan G. Kochan (2001) : "Programming In C" ; CBS Publishers & Distributors, ISBN PB : CBS0000031
4. Stephen G. Kochan (2004): **"**Programming in C"; 3rd Edition, Sams, **ISBN-10:**0672326663, **ISBN-13:** 978-0672326660
5. Kelly Stan and Bootle (1988): "Mastering turbo C"; BPB Publications
6. Stan Kelly Bootle (1988): "Mastering Turbo C"; Wiley John & Sons Incorporated, ISBN-13: 9780895884626 , ISBN: 0895884623
7. Kanetkar Yashwant (2006) : "Let us C" ; 9th Edition , BPB, **ISBN:** 8183331637, **ISBN-13:** 9788183331630,
8. E Balaguruswamy (2007) : "Programming In C#"; Tata Mgraw Hill, **ISBN:** 0070667578 **ISBN-13:** 9780070667570, 978-0070667570
9. Robert Lafor (2001) : "Object - Oriented Programming in C" ; Sams , 4th Edition, **ISBN:** 0672323087, **ISBN-13:** 9780672323089, 978-0672323089
10. Robert Lafore (1995) : "Object Oriented Programming in C++"; Galgotia Publications.

# SEMESTER - II

# PAPER – 201

# ESTIMATION THEORY

**UNIT I:**

- Concept of Estimator and Estimate, Different measures of closeness of an estimator : Pitman's closeness. Some desirable properties of estimators: Definition of Unbiasedness and Biasedness, Definition of Consistent estimator, Theorem of derivation of Consistent estimator, Efficiency: Best linear combination of unbiased estimator, BAN estimators. Sufficient statistics.

**UNIT II:**

- Neyman factorization theorem for discrete case, Minimal sufficient statistics, complete sufficient statistics, Minimum variance unbiased estimation: Lower bound of variance of an unbiased estimator, Cramer–Rao inequality, Minimum variance bound unbiased estimators, condition of existence of Minimum Variance Bound Unbiased Estimator. Chapman-Robbins inequality, Bhattacharya inequality, Rao-Blackwell theorem. Lehmann –Scheffe theorem, One parameter family of exponential distribution, Concept of finding uniformly minimum variance unbiased estimator (UMVUE)

**UNIT III:**

- Maximum likelihood estimator and its properties. Method of maximum likelihood, other methods of estimation: Method of moments, Method of minimum chi-square, Method of modified minimum chi squares, Method of scoring, MLE for grouped data, Method of scoring, Location invariance and scale invariance estimator and parameter, Pitman estimators for location and scale parameters.

**UNIT IV:**

- Confidence intervals: Methods of finding confidence interval, Large sample confidence intervals, confidence intervals for parameters of elementary distributions, confidence bounds of fixed length, Stein's two-stage procedure.

## REFRENCES


1. Rohatagi V.K. : "An Introduction to Probability Theory and Mathematical Statistics".
2. Rao C.R. : "Linear Statistical Inference and its Applications"; John Wiley.
3. Mood A.M., Graybill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hill.
4. Lehmann E.L.: "Theory of Point Estimation"; John Wiley.
5. Ferguson T.S.: "Mathematical Statistics: A Decision Theoretic Approach"; Academic Press.
6. Zacks S. : "Theory of Statistical Inference"; John Wiley.

# PAPER – 202

# MULTIVARIATE ANALYSIS

**UNIT I:**

- Multivariate distributions: Multinomial distribution, Marginal and Conditional distributions, Characteristic function. Multivariate Normal distribution, Characteristic function, Marginal and conditional distributions, Distribution of linear function. Distribution of sample mean vector.

**UNIT II:**

- Distribution of sample generalized variance. Wishart Distribution: p.d.f of Wishart distribution, Properties of Wishart distribution, Additive property, Distribution of HWH', marginal distribution of $W_{11}$, distribution of h'wh/h'$\sum$h, h'$\sum^{-1}$h/h'$w^{-1}$h, Characteristic function.
- Null and Non-null distribution of sample correlation coefficient r. Definition of Multiple and partial correlation coefficients. Null distributions of sample multiple and partial correlation coefficients. Testing of $H_0$: (i) $\rho = 0$, (ii) $\rho = \rho_0$ (iii) $\rho_{1(2.p)} = 0$ (iv) $\rho_{12.3....p} = 0$ (v) $\rho_{12.3....p} = \rho_0$

**UNIT III:**

- Hotelling $T^2$ statistic. Null distribution of $T^2$, application in tests on mean vector for one and two multivariate normal populations and in testing equality of the components of mean vector (Problem of symmetry).
- Multivariate Analysis of variance (MANOVA): One-Way classification problem.

**UNIT IV:**

- Classification Problem and Fisher's linear discriminant function, Probabilities of misclassification, Classification with more than Two multivariate normal populations.
- Concept and application of (i) Factor analysis (ii) Principal Component analysis and (iii) Canonical Correlation analysis.

## REFERENCES


1. Anderson T. W. : "An Introduction to Multivariate Statistical Analysis"; John Wiley.
2. Johnson and Wichern : "Applied Multivariate Statistical Analysis".
3. Khirsagar A. M. : "Multivariate Analysis"; Marcel Dekker.
4. Morrison D.F.: "Multivariate Statistical Methods"; McGraw Hill.
5. Muirhead R.J. : "Abstracts of Multivariate Statistical Theory"; John Wiley.
6. Seber G.A.F. : "Multivariate Observations"; John Wiley.
7. Srivastava and Khatri C.G.: "An Introduction to Multivariate Statistics"; North Holland.

# PAPER – 203

# SAMPLING THEORY

**UNIT I:**

- **Basic concepts of sample survey and sampling theory:**
  - Concepts of population and sample need for sampling, Census and sample survey, basic concepts in sampling, organizational aspects of survey sampling, sample selection and sample size.
  - Concept of parameter, statistic, sampling distribution and standard error, revision of properties of good estimator and criteria for comparison of estimators.

**UNIT II:**

- **Basic Probabilistic Sampling techniques:**
  - Simple random sampling
  - Stratified sampling
  - Systematic sampling and
  - Cluster sampling (with equal and unequal cluster sizes)

**UNIT III:**

- **Methods of estimation in sampling:**
  - Ratio method of estimation- Ratio estimator , unbiased ratio estimator and almost unbiased ratio estimator
  - Product method of estimation
  - Regression method of estimation
  - Difference estimator

**UNIT IV:**

- **Advanced Probabilistic sampling techniques:**
  - Two–stage sampling and its generalization.
  - Two phase sampling for ratio and regression estimators.
  - Probability Proportional to size sampling (with and without replacement), Sen-Midzuno sampling scheme

## REFERENCES


1. Cochran W. G. : “Sampling Techniques”; John Wiley & Sons, Inc., New York.
2. Hansen M. H., et al.: “Sample Survey Methods and Theory”; John Wiley & sons, Inc., New York.
3. Kish L. : “Survey Sampling”; John Wiley & Sons, Inc., New York.
4. Murthy M. N. : “Sampling Theory and Methods”; Statistical Publishing Society, Calcutta.
5. Raj D. : “Sampling Theory”; McGraw-Hill Book co., New York.
6. Raj D. : “The Design of Sample Surveys”; McGraw-Hill Book Co., New York.
7. Sukhatme P.V., et al.: “Sampling Theory of Surveys with Applications"; The Iowa State Univ. Press, Ames, Iowa, USA and Indian Society of Agricultural Statistics, New Delhi.
8. Yates F. : "Sampling Methods in Censuses and Surveys"; Charles Griffin & Co. Ltd., London.
9. Goulden C. H. : "Methods of Statistical Analysis", Asia Publishing House, Bombay.
10. Snedecor G.W. and Cochran W.G. : "Statistical Methods"; The Iowa State Univ. Press, Ames, Iowa, USA.

# PAPER – 204

# ACTUARIAL STATISTICS

**UNIT I:**

- Basics of Probability & Interest: Theory of Interest, Variable interest rates, continuous time payment streams.
- Interest & Mortality: Annuities, Loan Amortization and Mortgage Refinancing, Mortality and Analytical models.

**UNIT II:**

- Life Tables: Concepts of Life Tables, Assumptions related to life tables, columns of life tables, Complete and Abridged life tables, Construction of life tables, Estimation from life table data.

**UNIT III:**

- Expected present values of payments, Continuous contracts & residual life, Premium calculations, m-payment net single premiums
- Population functions and indicator notations, Stationary population concepts

**UNIT IV:**

- Risk models: Proportional Hazard models, excess risk models, multiple decrement models, death rate estimators, causes specific life insurance premiums.

## REFERENCES

1. Barcley G.W. (1970). Techniques of Population Analysis. John Wiley, New York.
2. Borowiak, D.S., and A. F. Shapiro. (2013). Financial and Actuarial Statistics: An Introduction, Second Edition. CRC Press.
3. Donald, D.W.A. (1970). Compound interest and annuities, Second Edition, The Institute of Actuaries and the Faculty of Actuaries at the University Press.
4. Spurgeon, E.T. (2011), Life Contingencies, Third Edition, Cambridge University Press.
5. Eric V. Slud (2001): Actuarial Mathematics and Life Table Statistics (Mathematics Department, University of Maryland)

# PAPER – 205

# LINEAR MODELS

**UNIT I:**

- The general linear model: Gauss-Markoff set up, least squares, and generalized least squares, Normal equations and least squares estimates, estimation of linear parametric functions, variances and covariances of least squares estimates, estimation with correlated observations.

**UNIT II:**

- Least squares estimates with restrictions on parameters, simultaneous estimates of linear parametric functions, Canonical form of the linear hypothesis model and Error and Estimation spaces.

**UNIT III:**

- Estimation of scale parameter in the general linear model by quadratic functions. Necessary and sufficient conditions for (i) a quadratic form to be distributed as chi-square (ii) independence of a linear form and a quadratic form (iii) independence of two quadratic forms.

**UNIT IV:**

- Cochran's theorem and its generalizations.
- Tests of hypotheses regarding parameters of a general linear model, tests involving linear functions of parameters, tests of sub hypotheses.

## REFERENCES

1. Rao C.R. (1973): "Linear Statistical Inference and its Applications"; 2nd Ed., John Wiley and Sons, Inc.
2. Searle S.R. (1971): "Linear Models".
3. Seber G.A.F. (1977): "Linear Regression Analysis".
4. Graybill F. A. (1961): "An Introduction to Linear Statistical Models".
5. Kshirsagar A.M.(1983): "A Course in Linear Models".

# SEMESTER - III

# PAPER – 301

# TESTING OF HYPOTHESES

**UNIT I:**

- **Basic concepts of testing of hypotheses**
  Statistical Hypotheses- Simple and Composite. Statistical tests, Critical region, randomized test, non–randomised test, Errors of Type I and Type II, Size and Power of a test
- **MP and UMP tests**
  Neyman–Pearson's Lemma & Generalized Neyman–Pearson's Lemma and its applications to find Most Powerful test and UMP tests for families of distributions admitting monotone likelihood ratio, two sided hypotheses

**UNIT II:**

- **Unbiasedness for testing of hypotheses:**
  Similar test, relationship with UMP unbiased test, UMP similar test and its application for one parameter exponential family, Similarity and completeness, tests with Neyman structure, UMP unbiased tests for multi-parameter exponential families

**UNIT III:**

- **Concept of Invariance in testing of hypotheses:**
  Maximal invariant test, most powerful invariant test
- **Concept of least favourable distribution and its use in testing of hypotheses**

**UNIT IV:**

- **Liskelihood ratio tests:** Likelihood ratio test for simple and composite hypotheses.

**UNIT V:**

- **Sequential testing of hypotheses:**
  Wald's sequential probability ratio test (SPRT), Properties of SPRT, approximate bounds, OC and ASN functions, Efficiency of SPRT, Fundamental identity of sequential analysis and its use to obtain OC and ASN functions of SPRT.

## REFERENCES


1. Ferguson T.S. : "Mathematical Statistics"; Academic Press.
2. Kendall M.G. and Stuart A.: "The Advanced Theory of Statistics"; Vol. 2., Ed. IV, Charles and Griffin.
3. Lehman E.L. : "Testing Statistical Hypotheses"; Wiley Eastern.
4. Mood A.M., Grabill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hills, International Student Ed. III.
5. Rao C.R. : "Linear Statistical Inference and its Applications"; Wiley Eastern, EdII.
6. S. Wilks : "Mathematical Statistics", Wiley New York.
7. S. Zacks : "The Theory of Statistical Inference"; Wiley New York.
8. Goon A. M., Gupta M. K. and Dasgupta B. : "An Outline of Statistical Theory" Vol.1, 2; World press.
9. Rohatgi V.K.: "Introduction to Probability Theory and Mathematical Statistics"; Wiley Eastern.

# PAPER – 302

# ECONOMETRICS

**UNIT I:**

- Econometrics, Introduction to econometric models. Review of **Single Equation method OLS estimation:** Estimation, Prediction, and tests of hypotheses, G.L.M. and generalized least squares estimation. Aitken's generalized least square (G.L.S) estimator,

**UNIT II:**

- GLM with stochastic regressors. Instrumental variables, estimation, consistency property, asymptotic variance of instrumental variable estimators.
- **Dummy and Lagged variables:** The nature of dummy variables, caution in the use of dummy variables, ANOVA models with two qualitative variables, regression with a mixture of quantitative and qualitative regressors: the ANCOVA models, the dummy variable alternative to the chow test, interaction effects using dummy variables, the use of dummy variables in seasonal analysis, piecewise linear regression.

**UNIT III:**

- **Autocorrelation :** Introduction, its consequences and tests and remedial measures to it.
- **Heteroscedasticity:** Problem of hetroscedasticity, Consequence of hetroscedasticity, Tests for detecting the presence and nature of hetroscedasticity, Methods for handling hetroscedasticity. Grouping of observations.
- **Multicollinearity:** Detection and consequences, tools for handling multicollinearity, ridge regression and properties of ridge regression.

**UNIT IV:**

- **Simultaneous equation system:** structure and models, typology of economic relations, structural form, reduced form and final form of an economic model. Problem of identification under linear homogeneous and Covariance restrictions. Rank and Order conditions of Identification, Restrictions on structural parameters.

- **Methods of estimation:** Limited information models, indirect least squares. Two stage least squares, limited information maximum likelihood (LIML), fuIl information methods. Three stage least square (3SLS) and full information maximum likelihood (FIML). K-class estimators, Instrumental variable method of estimation, 3-SLS estimation.

## REFERENCES


1. Apte P.G.: “Text Book of Econometrics”; Tata McGraw Hill.
2. C. F. Charist: “Econometric Models and Methods”; John Wiley.
3. Chatterjee and Price B.: “Regression Analysis by Example”; John Wiley & Sons.
4. Cramer: “Empirical Econometrics”; North Holland.
5. D.Gujarati: “Basic Econometrics”; McGraw Hill.
6. Intriligatore,M.D. : Economic models -techniques and applications, Prentice Hall
7. Intrilligtor H.: “Econometric Methods, Techniques and Applications”; Prentice Hall Pub. Co.
8. J. Jonston: “Econometric Methods”; McGraw Hill, Kogakusha Ltd.
9. Jan Kmenta : Elements of Econometrics, University of Michigan Press
10. Judge, G.C., Hill, R, C. Griffiths, W.E., Lutkepohl, H. and Lee, T-C. (1988). Introduction to the Theory and Practice of Econometrics, Second Edition, John Wiley & Sons.
11. Kendall, M.G. and Stuart, A. (1968). The Advanced Theory of Statistics (Vol. III), Second Edition, Charles Griffin.
12. Klein L.R.: “An Introduction to Econometrics”; Prentice Hall of India.

13. Klein, L.R. : Applied Economics, Taylor and Francis
14. Kmenta, J. (1986). Elements of Econometrics, Second Edition, Mac Millan.
15. Kontsoyiannis A.: “Theory of Econometrics”; Mac Millan press.
16. Maddala, G.S. : Econometrics, North Holland
17. Malinvad E.: “Statistical Methods in Econometrics”; North Holland.
18. Theil H. C.: “Introduction to the Theory and Practice of Econometrics”; John Wiley.

# PAPER – 303

# OPERATIONS RESEARCH – I

**UNIT I:**

- **Linear Programming:**
  - Definition of linear programming problem (LPP)
  - Formulation of LPP .
  - Solution of LPP by Graphical and Simplex Method (including Big-M and Two-phase method)

**UNIT II:**

- **Transportation and Assignment Problems:**
  - Definition of Transportation Problem (TP)
  - Special structure of TP
  - Methods for getting basic feasible solution to TP
  - Methods for getting optimum solution to TP
  - Unbalanced TP
  - Definition of Assignment Problem (AP)
  - Algorithm for solving an AP
  - Unbalanced AP
  - Routing Problem

**UNIT III:**

- **Duality:**
  - Definition of Dual Problem.
  - Rules for converting any Primal into its Dual
  - Properties of Duality
  - Dual-Simplex Method
- **Simulation**
  - Introduction & definitions
  - Types of simulation
  - Uses & limitation
  - Phases of simulation Model
  - Even type simulation
  - Monte-Carlo Simulation & its applications
  - Advantages and Disadvantages

**UNIT IV:**

- **Inventory Management Systems:**
  - Definition
  - Costs involved in Inventory Problems
  - Classical EOQ Models without and with shortages
  - Multi-item Deterministic Models
  - Probabilistic Inventory Models
  - Inventory Models with Price Breaks

## REFERENCES


1. K. Swarup, Gupta P.K. and Man Mohan : “Operations Research”; S.Chand & Co.,New Delhi.
2. G. Hadley : “Linear Programming”; Oxford & IBH Pub. Co.
3. Murthy K.G. : “Linear and Nonlinear Programming”.
4. Kasana H.S. and Kumar K.D. : “Introductory Operations Research”; Springer.
5. Kapoor V.K. : “Operations Research”; S.Chand & Co.,New Delhi.
6. Sharma S.D. : “Operations Research”; Kedar Nath Ram Nath & Co. Publishers, Meerut.

# PAPER – 304

# INTRODUCTION TO STATISTICAL SOFTWARES

**UNIT I:**

- **SPSS:**
  - SPSS Introduction
  - Starting SPSS
  - Types of Data
  - Levels of Measurement
  - Missing Values
  - Important Files // database files
- **Data Management**
  - Selecting Cases
  - Standardizing Data
  - Transformation of Data
  - Split File
  - Variable and Value Labels
  - Recode Variables/Visual Binning
  - Random Sample of the Data
  - Creating a Population Variable
  - Multi Response
  - Time Saving Features / SPSS MACRO

**UNIT II:**

- **Basic Data Analysis**
  - Descriptive Statistics
  - Frequency Tables/Cross Tabs
  - Independent T test
  - Paired T Test
  - One-Way ANOVA
  - Correlation / Regression
- **Interpret the Results**

  Presentation with live data

**UNIT III:**

**R:**

- **Introduction to R**
  - Background and resources
  - Installing R.
  - R console.
  - R commander
  - Command and syntax
  - Packages and libraries
  - Help in R
  - Workspace in R
- **Data Structures**
  - Introduction to data structure
  - Vectors
  - Matrices
  - Arrays
  - Lists
  - Factors
  - Data frames

- Importing and Exporting data
- Data types

- **Frequencies & Descriptive Statistics**
  - Frequency
  - Measure of central tendency
  - Measure of Dispersion
  - Measure of skewness
  - Box and Whisker part
- **Data management**
  - Split
  - Find and replacement
  - Manipulations with alphabets
  - Evaluation of strings
  - Data frames.

**UNIT IV:**

- **Graphical Analysis**
  - Creating a simple graph
  - Modifying the points and line of graph
  - Modifying title and subtitle of a graph
  - Modifying axes of the graph
  - Adding additional elements to graph
  - Adding legend on a graph
  - Special graph
  - Multiple plots
- **Comparing Populations**
  - Cross tabulation
  - One sample t test
  - Independent sample t test
  - Paired sample t test
  - One way ANOVA
- **Bivariate Data Analysis**
  - Correlation
  - Simple linear regression
  - Multiple linear regression

- **Conditional executions and loops**
  - If loop
  - While loop
  - For loop

## REFERENCES


1. Miller R. L., Ciaran Acton and Fullerton D. A., John Malthy (2009), "SPSS for Social Scientists"; 2nd Edition, Palgrave Macmilan. ISBN: 9780230209930.
2. Wagner W. E. III (2006): "Using SPSS for Social Statistics and Research Methods"; SAGE Publications, ISBN-13: 9781412940771.
3. Einsprucho E. L.: "An Introductory Guide to SPSS for Windows"; ISBN:1-412904153.
4. Pandya K. and Bulsari S.: "Enjoy Statistics with SPSS for Windows"; Popular.
5. Gaur A. S. and Gaur S. S(2009).: "Statistical Methods for Practice and Research- A guide to data analysis using SPSS"; 2nd Ed., Sage Publications, New Delhi.
6. George: "SPSS For Windows: Step By Step"; 8th Ed., Pearson, ISBN: 8131724298, 9788131724293.

7. Sudha G. Purohit, Sharad D. Gore, and Shailaja R. Deshmukh (2008), “Statistics using R, Second edition” , Narosa Publishing House, ISBN-978-81-8487-455-6
8. Dr. Mark Gardener (2015), “Beginning R: The statistical programming language”, Wiley, ISBN-978-81-265-4120-1
9. Jared P. Lander (2014), “R for everyone advance analytics and graphics”, Addison Wesley data & analytics series, Dorling Kindersley (India) Pvt. Ltd., ISBN-978-93-325-3924-2
10. Yanchang Zhao and Yonghua Cen (2014), “Data mining application with R”,Elsevier, ISBN-978-93-5107-218-8
11. Nina Zumel and John Mount (2015), “Practical data science with R”, Dreamtech Press, ISBN-978-93-5119-437-8
12. Paul D. Lewis (2010), “R for medicine and biology”, Jones and Bartlett Publishers, ISBN-978-0-7637-5808-0.

# ELECTIVE PAPERS

# PAPER – 3051

# DATA MINING

**UNIT I:**

- Overview of Database Management System (DBMS)
  - Introduction to Database Languages
  - Advantages of DBMS over file processing systems.

**UNIT II:**

- Relational Database Management System
  - Types of Keys, Entity relationship model, EER
  - Database Structure: DDL, DML, DCL,TCL
  - Types of Data Models
  - PL/SQL-functions, triggers and procedures

**UNIT III:**

- Data Mining
  - Types of data
  - Process of data mining
  - Application of datamining

**UNIT IV:**

- Supervised Learning
  - Multiple Regression/Stepwise Regression
  - Logistic Regression/Multi-Nomial regression
  - K-nearest neighbors (KNN)
  - Bayes classifier
  - Nearest neighbor classifier

**UNIT V:**

- Supervised Learning
  - Self-organizing map
  - Clustering procedures
  - Association Rules

## REFERENCES

1. Jiawei Han, Micheline Kamber(2006) : "Data Mining"; II-Ed., Morgan Kaufmann Publishers, ISBN: 1558609016, 9781558609013
2. Hillol Kargupta, Jiawei Han, Philip S. Yu(2008): Next Generation of Data Mining, CRC Press, ISBN: 1420085867, 9781420085860
3. Margaret H. Dunham: "Data Mining - Introductory and Advance Topics"; Pearson Edu., ISBN: 8177587854, 9788177587852
4. An Introduction to Database System- C. J. Date-Narosa
5. Database System Concepts-Henry F. Korth & Abraham Silberschatz-McGraw-Hill
6. Principles of Database System-J. Ullman-Galgotia Pub.
7. Oracle PL/SQL Programming-Feuerstein & Pribyl, O'Reilly, Shroff Publishers & Distributors Pvt. Ltd.
8. Manual of RDBMS

# PAPER 3052

# STOCHASTIC PROCESSES

**UNIT I:**

- Stochastic Process, Markov Process and Markov chain.
- Markov chain with finite and countable state space, limiting behavior of n-step transition probabilities, stationary process.

**UNIT II:**

- Markov Processes in continuous time (Poisson Process, Birth and death processes), Classification of states of a Markov chain.
- Random walks, Gambler's ruin.

**UNIT III:**

- Queueing Theory: Definition, Characteristics of a queueing system, Poisson Process and Exponential distribution, Classification of queues, Birth model, Death model, Birth death model.

**UNIT IV:**

- Detailed study of M/M/1 queueing models.

**UNIT V:**

- Detailed study of M/M/C queueing models.

## REFERENCES

1. Karlin S.: "A First Course in Stochastic Processes"; Academic Press.
2. Parzen E.: "Stochastic Processes"; Holden-Day.
3. Feller W.: "An Introduction to Probability Theory and its Application"; Vol.I, 3rd Ed., John Wiley.
4. Hoel P.G., Port S. C. and Stone C. J.: "Introduction to Stochastic Processes"; Houghton Mifflin Co., Bosten.
5. K. Swarup, Gupta P.K. and Man Mohan: "Operations Research"; S. Chand & Co., New Delhi.
6. Sharma S.D.: "Operations Research"; Kedar Nath Ram Nath & Co. Publishers, Meerut.

# PAPER – 3053

# MATHEMATICAL ECONOMICS

**UNIT I:**

- Theory of Consumer Behaviour:
  Meaning of Utility, Utility function, Indifference curve, Rate of Commodity substitution, Utility maximization, Choice of utility index, simple demand function, compensated demand function, demand curves, Elasticity of demand, price elasticity of demand, income elasticity of demand, cross elasticity of demand, Total revenue, marginal revenue, average revenue, and their relationship

**UNIT II:**

- Theory of the firm:
  Production function, Product curves, Marginal product, Isoquents, Elasticity of substitution, Homogeneous production function, properties of homogeneous production function, Constant elasticity of substitution (CES) production function, Joint products, properties of Cobb-Douglas production function, cost function, cost elasticity of a commodity

**UNIT III:**

- Market equilibrium:
  Perfect competitive market, Imperfect competitive market, Monopoly, profit maximization of a monopolist, price discrimination, market discriminations, perfect discrimination, Applications of monopoly, examples. Duopoly, duopoly for homogeneous product and their applications, examples.

**UNIT IV:**

- Input – Output Analysis : Leontief's static models for inter industry relations. The Leontief's open and closed system.
- Growth Models : Classical and Keynesian simple income determination models. Concepts of multipliers and accelerator. Harrod-Domar model, Hicks-Samuelson model, Solow's Growth model. Mahalanobis two and four sector models.

## REFERENCES

1. Henderson and Quant: Microeconomic theory, McGraw Hill
2. Karmel P.H. : "Applied Statistics for Economics".
3. Sen A.K. : Growth Economics : Penguin Modern Economic Reading Edition.
4. Pillai S. : Economic & Business Statistics; Progressive Corporation Pvt. Ltd.
5. Mukhopadhyay P. : Applied Statistics; New Central Book Agency (P) Ltd.
6. Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics; Sultan Chand & Sons.

# PAPER – 3054

# STATISTICAL QUALITY CONTROL AND RELIABILITY

**UNIT-I:**

- The meaning of Quality & Quality improvement
- Introduction of statistical quality control
- Statistical process control
  - Introduction
  - Measure of location and variability
  - Process of control charts for variables & attribute
  - Process of control limits
  - Out of control criteria
- Process and measurement system capability analysis

**UNIT-II:**

- Cumulative sum chart
- Statistical product control
  - Introduction
  - Standard plans for attributes
  - Plan for acceptance sampling by measurement

**UNIT-III:**

- Total Quality Management
  - Meaning and important concepts
  - Importance of quality management
  - Total quality management models
  - Six sigma and Quality management
  - Kaizen process
  - Strategic quality planning and total quality management
  - The cost of quality
  - Productivity
  - ISO 9001

**UNIT-IV:**

- Reliability
  - Basic concepts and distributions for product life, failure rate.
  - Hazard function, Reliability function for Exponential, Normal, Lognormal, Weibull and Gamma Distributions.
  - Analysis of Complete Data.
  - Linear analysis and maximum likelihood analysis of censored data for exponential distribution only.
  - System reliability.
  - Introduction of Bayes Methods in Reliability.
  - Accelerated life testing.

## REFERENCES


1. Hopper A.G. : "Basic Statistical Quality Control"; McGraw Hill, London.
2. Gupta R.C. : "Statistical Quality Control"; Khanna Publishers, New Delhi.
3. Ryan T.P. : "Statistical Methods for Quality Improvement"; John Wiley & Sons.
4. Omachonu V.K. and Ross J.E. : "Principles of Total Quality"; S.Chand & Co., New Delhi.
5. Sinha S.K. : "Reliability and Life Testing"; Wiley Eastern Ltd., New Delhi.
6. Bazovksy I.: "Reliability Theory and Practice"; Prentice Hall International Series in Engineering.
7. Grant E. L. and Leavenworth R. : "Statistical Quality Control" ; Tata Mc Graw Hill Publishing Co. Ltd., New Delhi.
8. Irving W.B. : "Elementary Statistical Quality Control"; Marcel Dekker, Inc., New York.
9. Douglas C. Montgomery: Introduction to statistical quality control.

# SEMESTER - IV

# PAPER – 401

# DECISION THEORY

**UNIT I:**

- **Review of basic elements of statistical decision problem:**
  Various inference problems viewed as decision problems.

**UNIT II:**

- **Introduction to Decision Analysis:**
  Pay-off table for decisions and discussion of decision criteria, Decision trees.

**UNIT III:**

- **Main theorems of Decision Theory:**
  Natural ordering of decision rules. Complete and essentially complete classes of decision rules. Admissibility of Bayes rules. Existence of Bayes decision rules and of Minimax complete class when parameter space is finite and the risk set is closed and bounded from below.

**UNIT IV:**

- **Invariant decision problems**
  Invariant decision rules, Admissible, minimax invariant rules.

**UNIT V:**

- **Non-Parametric Methods for Testing of hypotheses:**
  - Tests for one sample
  - Tests for two related samples
  - Tests for two independent samples
  - Tests for k related samples
  - Tests for k independent samples
  - Tests of significance of measures of correlation

## REFERENCES


1. Berger J.O. : "Statistical Decision Theory"; Springer –Verlag Pub. Co., New York.
2. Gibbons J.D. : "Nonparametric Statistical Inference"; McGraw Hills.
3. Ferguson T.S. : "Mathematical Statistics"; Academic Press.
4. Kendall M.G. and Stuart A.: "The Advanced Theory of Statistics"; Vol. 2., Ed. IV, Charles and Griffin.
5. Mood A.M., Grabill F. and Boes D.C. : "Introduction to the Theory of Statistics"; McGraw Hills, International Student Ed. III.
6. Sedney Seigal : "Nonparametric Methods for Behavioral Sciences"; McGraw Hill.
7. Gibbons J.D. and Pratt J.W. : "Concepts of Nonparametric Theory"; Springer-Verlag.
8. Daniel W.W. : "Applied Nonparametric Statistics"; PWS-KENT publishing Co., Boston.
9. Conover W.J. : "Practical Nonparametrics"; John Wiley.
10. Wald A. : "Sequential Analysis"; Wiley
11. Hettmansperger, T.P. (1984). Statistical inference Based on Ranks, John Wiley & Sons.
12. Randles, R.H. and Wolfe, D.A. (1979). Introduction to the Theory of Nonparametric Statistics, John Wiley & Sons.
13. Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley & Sons.

# PAPER – 402

# DESIGN OF EXPERIMENTS

**UNIT I:**

- General properties of incomplete block design; Concepts of connectedness, balance and orthogonality.

**UNIT II:**

- Balanced incomplete block design (BIBD) and symmetric balanced incomplete block designs, Resolvable BIBD, Affine Resolvable BIBD.
- Intra Block Analysis of BIBD

**UNIT III:**

- General theory of analysis of experimental designs with one way and two way elimination of heterogeneity (intrablock analysis only).
- Missing plot technique, its application to randomized block, Latin square and balanced incomplete block designs.
- Youden square and Crossover design.

**UNIT IV:**

- General theory of symmetric factorial experiments; concepts of total and partial confounding and $2^n$ confounded experiments.
- Construction of total and partially confounded symmetric $2^n$ factorial experiments.

## REFERENCES


1. Chakraborti M.C. : “Mathematics of Design of Experiments”.
2. Dey Aloke : “Theory of Block Designs”.
3. Raghva Rao D. : “Construction and Combinatorial Problems in Design of Experiments”.
4. Kempthorne O. : “The Design and Analysis of Experiments”.
5. Federer W.T. : “Experimental Designs”.
6. Das M. N. and Giri N. : “Design and Analysis of Experiments”.
7. Ogawa J.: “Statistical Theory of the Analysis of Experimental Designs”.
8. John P.W.M. : “Statistical Design and Analysis of Experiments”.
9. Joshi D. D. : “Linear Estimation and Design of Experiments”.

# PAPER – 403

# OPERATIONS RESEARCH – II

**UNIT I:**

- Sensitivity Analysis:
  - Basic concepts
  - Changes in the coefficient of objective function
  - Changes in the components of vector b and of Matrix A
  - Addition / Deletion of variable in the problem
  - Addition / Deletion of constraint in the problem

**UNIT II:**

- Integer Programming:
  - Introduction
  - All and mixed integer programming (IPP) problems
  - Gomory's al1-IPP algorithm
  - The branch and bound technique
  - Zero - one programming
- Sequencing Problems:
  - Definition, Notations and Assumptions
  - Solution of sequencing problem.
  - Problems with n-jobs and 2-machincs
  - Problems with n-jobs and 3-machines
  - Problems with 2-jobs and m-machines

**UNIT III:**

- PERT / CPM:
  - Basic concepts .
  - Construction and Time Calculation of the Network
  - Determination of Float and of the Critical Path
  - Crashing a Project
  - Scheduling a Project
  - Resource Analysis and Allocation
  - Application of PERT/ CPM

**UNIT IV:**

- Replacement Theory:
  - Types of Replacement Problem
  - Replacement of Items that Deteriorate
  - Replacement of Items that fails completely and that of Staff
- Goal Programming:
  - Definitions and Concepts
  - Formulation of Goal Programming Problem (GPP)
  - Solution of GPP by Graphical and Extended Simplex Methods

## REFERENCES

1. K. Swarup, Gupta P.K. and Man Mohan : “Operations Research”; S.Chand & Co.,New Delhi.
2. G. Hadley : “Linear Programming”; Oxford & IBH Pub. Co
3. Murthy K.G. : “Linear and Nonlinear Programming”.
4. Kasana H.S. and Kumar K.D. : “Introductory Operations Research”; Springer.
5. Kapoor V.K. : “Operations Research”; S.Chand & Co.,New Delhi.
6. Sharma S.D. : “Operations Research”; Kedar Nath Ram Nath & Co. Publishers, Meerut.

# ELECTIVE PAPERS

# PAPER 4041

# ECONOMIC& BUSINESS STATISTICS

**UNIT I:**

- Index Numbers: Price, Quantity and Value indices. Price Index Numbers: Construction, Uses, Limitations, Tests for index numbers, Chain Index Number. Consumer Price Index, Wholesale Price Index and Index of Industrial Production – Construction of index numbers and uses. Cost of Living Index Number and Various Official Index Numbers, HDI (Human Development Index)

**UNIT II:**

- Demand Analysis :
  Concept related to demand and supply, price elasticities of demand and supply, Methods of determining demand and supply curves for cross section data and time series data, Leontief's method, Pigou's Method, Engels Curves, Pareto's Law of Income Distribution.

**UNIT III:**

- Time Series Analysis: Definition and importance of time series analysis. Components of a Time series. Different methods for determination of trend, Methods for elimination of seasonal components. Determination of cyclic components. Variate difference method and their merits and demerits.

**UNIT IV:**

- Stationary Time series, Box-Jenkins Models, Introduction to Autoregressive (AR) Models, Moving Average (MA) Models, Mixed Autoregressive Moving Average (ARMA) Models.Autoregressive Integrated Moving Average (ARIMA) Models. Properties of these models. Forecasting Techniques, Seasonal ARIMA model, Introduction to conditional Heteroscedasticity model; Volatility models, ARCH model, GARCH model, properties, estimation and forecasting of these models.

## REFERENCES


1. Allen R. G. D. (1975). Index Numbers in Theory and Practice, Macmillan.
2. Kendall M. : "Time Series"; Charles Griffin and Company.
3. Box and Jenkins : Time Series Analysis : Forecasting and Control; Holden Day Pub.
4. Chatfield C. : The Analysis of Time Series : Theory and Practice; Chapman and Hall.
5. Waller Vancuels : Applied Time Series and Box Jenkins Models.
6. Karmel P.H. : "Applied Statistics for Economics".
7. Sen A.K. : Growth Economics : Penguin Modern Economic Reading Edition.
8. Pillai S. : Economic & Business Statistics; Progressive Corporation Pvt. Ltd.
9. Mukhopadhyay P. : Applied Statistics; New Central Book Agency (P) Ltd.
10. Gupta S.C. and Kapoor V.K. : Fundamentals of Applied Statistics; Sultan Chand & Sons.
11. Anderson. T. W. (1971). The Statistical Analysis of Time Series Wiley, N. Y.
12. Montgemory, D. C. Johnson L. A (1990) Forecasting and Time Series Analysis, McGraw Hill.
13. Brockwell, P. J. and Davis R. A. (2006) Time Series: Theory and Methods (Second Edition) Springer-Verlag.

# PAPER 4042

## OFFICIAL STATISTICS

**UNIT I:**

- Statistical System in India: Central and State Government Organizations, Functions of Central Statistical Organization (CSO), National Sample Survey Organization (NSSO).

**UNIT II:**

- Official statistics: Meaning, methods of collection, limitations and reliability. Principal publications containing data on the topics such as population, agriculture, industry, trade, prices, labour and employment, transport and communications - Banking and finance.

**UNIT III:**

- National Income – Measures of national income - Income, expenditure and production approaches - Applications in various sectors in India.

**UNIT IV:**

- Measurement of income inequality: Lorenz curves, Application of Pareto and Lognormal as income distribution.
- Organization of large scale sample surveys. General and special data dissemination systems.

## REFERENCES

1. Bhaduri, A. (1990). Macroeconomics: The Dynamics of Commodity Production, Macmillan India Limited, New Delhi.
2. Branson, W. H. (1992). Macroeconomic Theory and Policy, Third Edition, Harper Collins Publishers India (P) Ltd., New Delhi.
3. C. S. O. (1990). Basic Statistics Relating to the Indian Economy.
4. C.S.O. (1995). Statistical System in India.
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6. C. S. O. (2016). Guide to Official Statistics.
7. Goon A. M., Gupta M. K., and Dasgupta. B. (2001), Fundamentals of Statistics, Vol. 2, World Press, India.
8. Mukhopadhyay P. (2011). Applied Statistics, Second Edition, Books & Allied Ltd, India.
9. Asthana, B.N. and Srivastava, S.S.(1984): Applied Statistics of India, Chaitanya Publishing House, Allahabad.

# PAPER 4043

# BIO-STATISTICS AND CLINICAL RESEARCH

**UNIT I:**

- Introduction to Bio-statistics, Sources of medical uncertainties, Managing medical uncertainties. Applications and uses of Bio-statistics as a science.
- Clinical trials: the need and ethics of clinical trials, bias and random error in clinical studies, conduct of clinical trials, overview of Phase I-IV trials, multi-center trials. Data management: data definitions, data collection systems for good clinical practice, protocol definition.

**UNIT II:**

- Design of clinical trials : parallel vs. cross-over designs, cross-sectional vs. longitude designs, review of factorial designs, objectives and endpoints of clinical trials, design of Phase I trials, design of single-stage and multi-stage Phase II trials, design and monitoring of Phase III trials with sequential stopping, design of bioequivalence trials.

**UNIT III:**

- Reporting and analysis: analysis of categorical outcomes from Phase I - III trials, analysis of survival data from clinical trials. Interim analysis method, motivating intent- to-treat analysis.

**UNIT IV:**

- Determining sample size. Surrogate endpoints: selection and design of trials with surrogate endpoints, analysis of surrogate endpoint data.

## REFERENCES


1. Prem Narayan, Bhatia & Malhotra (1979): Handbook of Statistical Genetics, IASRI, New Delhi.
2. Jain, J.R. (1982): Statistical techniques in quantitative genetics, Tata Mcgraw Hill.
3. Govindarajulu, Z. and Kargar, S. (2000): Statistical Techniques in Bioassay.
4. Finney, D.J (1971): Statistical Method In Bioassay, Griffin.
5. Finney, D.J (1971): Probit Analysis (3rd Edition), Griffin.
6. Weatherile, G.B. (1966): Sequential Methods in Statistics, Griffin.
7. Piantadosi, S. (1977): Clinical: A Methodologic Perspective. Wiley and Sons.
8. Jennison, C. and Turnbull, B.W (1999): Group Sequential Methods with Applications to Clinical Trials, CRC Press.
9. Flesis, J.L (1989): The Design and Analysis of Clinical Experiments. Wileyand Sons.
10. Marubeni, E. and Valsechhi, M.G (1994): Analyzing Survival Data From Clinical Trials and Observational Studies. Wiley and Sons.
11. Friendman,L.M., Furbery, C.D. and Demets, D.L.(1998): " Fundamental of clinical Trials " Springer Publication,3rd ed., Springer.
12. Duolaowang, A. B. (2006): Clinical Trials A Practical Guide to Design, Analysis, and Reporting, Published by Remedica, USA
13. A. Indrayan and L. Satyanarayana : Biostatistics for medical, nursing and pharmacy students, Eastern Economy Edition, Prentice hall India, ISBN 81-203-3054.
14. B. K. Mahajan: Method in Biostatistics for medical students and research work, Sixth edition, Jaypee Brothers medical publisher LTD. ISBN 81-7179-520-X.

# PAPER 4044

# STATISTICAL SIMULATION

**UNIT I:**

- Statistic simulations: generating random variables, simulating normal, gamma and beta random variables. Comparison of algorithms to generate random variables. Generating random variables from failure rates.

**UNIT II:**

- Simulating multivariate distributions, MCMC methods and Gibbs sampler, simulating random fields, simulating stochastic process. Variance reduction technique: importance sampling for integration, control variates and antithetic variables.

**UNIT III:**

- Simulating a non-homogeneous Poisson process, Optimization using Monte Carlo methods, simulated annealing for optimization. Solving differential equations by Monte Carlo methods.

**UNIT IV:**

- Jackknife and Bootstrap: Bootstrap methods, re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution. Confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations.

## REFERENCES

1. Fishman, G.S. (1996) Mante Carlo: Concepts, Algorithms and Applications. (Springer).
2. Rubinstein, R.Y. (1981); Simulation and the Monte Carlo Method. (Wiley).
3. Ripley, B.D. (1987) Stochastic Simulations (Wiley).
4. Ross, S. M. (2002) Simulation (Third Edition) (Academic).
5. Efron,B. and Tibshirani. R.J. (1993); An introduction to the Bootstrap.
6. Davison, A.C. and Hinkley,D.V. (1997) Bootstrap methods and their applications (Chapman and Hall).
7. Sho.J and Tu,D (1995); The Jackknife and the Bootstrap. Springer Verlag.