

# COTTON COLLEGE STATE UNIVERSITY

## DEPARTMENT OF STATISTICS

### Postgraduate Statistics Syllabus

#### DISTRIBUTION OF PAPERS/CREDITS (L+T+P format)

##### Semester – I

Paper Code	Paper Name	Credits
STA 701C	Mathematical Analysis	3 + 1 + 0
STA 702C	Linear Algebra	2 + 1 + 1
STA 703C	Measure Theory and Probability	3 + 1 + 0
STA 704C	Linear model and Design of Experiments-I & Sample Survey-I	2 + 1 + 1
STA 705E	Quantitative Techniques in Statistical Analysis	2 + 1 + 0

##### Semester – II

Paper Code	Paper Name	Credits
STA 801C	Distribution Theory	3 + 1 + 0
STA 802C	Statistical Inference – I	2 + 1 + 1
STA 803C	Design of Experiments-II and Sample Survey II	2 + 1 + 1
STA 804C	Simulation, LPP and Computer programming in C	2 + 1 + 1
STA 805E	Demography & Actuarial Statistics	2 + 1 + 0

##### Semester – III

Paper Code	Paper Name	Credits
STA 901C	Multivariate Analysis – I & Regression Analysis	2 + 1 + 1
STA 902C	Statistical Inference-II (Testing of Hypothesis )	2 + 1 + 1
STA 903C	Demography & Stochastic Processes	3 + 1 + 0
STA 904C	Optional : Special Papers A. Actuarial Studies – I B. Bio Statistics –I C. Operations research –I D. Survival Analysis – I E. Demography –I F. Astro Statistics – I	3 + 1 + 0
STA 905E	Official statistics & Statistics for National Development	2 + 1 + 0

## Semester - IV

Paper Code	Paper Name	Credits
STA 1001C	Non Parametric Statistical Inference and Bayesian Inference	2 + 1 + 1
STA 1002C	Multivariate Analysis – II & Elementary Data Mining	2 + 1 + 1
STA 1003C	Time Series & Econometrics	2 + 1 + 1
STA 1004C	Optional : Special Papers A. Actuarial Studies – II B. Bio Statistics –II C. Operations research –II D. Survival Analysis – II E. Demography –II F. Astro Statistics – II	3 + 1 + 0
STA 1005E	Use of packages for Statistical Data Analysis	1 + 1 + 1

### Special Papers

Paper Code	Suggested paper code	Paper Name	Credits
STA 1101C	STA 904C (A) or 904.1C	Actuarial Studies – I	3 + 1 + 0
STA 1102C	STA 904C (B) or 904.2C	Bio Statistics –I	3 + 1 + 0
STA 1103C	STA 904C (C) or 904.3C	Operations Research –I	3 + 1 + 0
STA 1104C	STA 904C (D) or 904.4C	Survival Analysis – I	3 + 1 + 0
STA 1105C	STA 904C (E) or 904.5C	Demography –I	3 + 1 + 0
STA 1106C	STA 904C (F) or 904.6C	Astro Statistics – I	3 + 1 + 0
STA 1107C	STA 1004C (A) or 1004.1C	Actuarial Studies – II	3 + 1 + 0
STA 1108C	STA 1004C (B) or 1004.2C	Bio Statistics –II	3 + 1 + 0
STA 1109C	STA 1004C (C) or 1004.3C	Operations Research –II	3 + 1 + 0
STA 1110C	STA 1004C (D) or 1004.4C	Survival Analysis – II	3 + 1 + 0
STA 1111C	STA 1004C (E) or 1004.5C	Demography –II	3 + 1 + 0
STA 1112C	STA 1004C (F) or 1004.6C	Astro Statistics – II	3 + 1 + 0

# SEMESTER-I

Paper: STA 701C

## MATHEMATICAL ANALYSIS

Credits: 4 (3+1+0)

### Part 1: Real Analysis and Special Functions

50 + 20 = 70

#### Unit I:

Real valued functions of a single variable, Rolle's theorem, Mean value theorems (Lagrange's and Cauchy's), Taylor's expansion, Extreme values.

#### Unit II:

Uniform convergence of sequence and series of functions, Cauchy's criterion and Weierstrass's M-test, Power series, Radius of convergence.

#### Unit III:

Functions of several variables, differentiation, partial derivatives of higher order, maxima minima of functions, constrained maxima – minima (Lagrange's Multiplier method).

#### Unit IV:

Concept of Multiple integrals, simple examples involving change of variables in multiple integrals, Dirichlet integral and Liouville's extension.

#### Unit V:

Convergence of Improper Integrals.

#### Unit VI:

Gamma and Beta Functions, Hypergeometric function, Bessel functions, Laguerre and Jacobi polynomials (definition and recurrence relation only).

### Part 2: Complex Analysis

30

Algebra of complex numbers, the complex plane, polynomials;

Analytic functions, Cauchy-Riemann equations.

Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle.

Taylor series, Laurent series, Calculus of residues

#### Reading List:

1. Apostol, T.M. (1985): *Mathematical Analysis*, Narosa, Indian Ed.
2. Courant, R. and John, F. (1965): *Introduction to Calculus and Analysis*, Wiley.
3. Miller, K.S. (1957): *Advanced Real Calculus*, Harper, New York.
4. Rudin, Walter (1976): *Principles of Mathematical Analysis*, Mc Graw Hill.
5. Andrews, G.E., Askey, Richard and Roy, Ranjan (2000): *Special functions* Cambridge University Press,
6. Rainville, E.D. (1960): *Special Functions*, The Macmillan Company, New York.
7. Priestly, H.A (1985): *Complex Analysis*, Clarenton Press, Oxford.
8. Conway, J.B. (1978): *Functions of one complex variable*, Springer-Verlag.

## SEMESTER-I

Paper: STA 702C

### LINEAR ALGEBRA

Credits: 4 (2+1+1)

#### Unit I:

Fields, linear spaces, subspaces, linear dependence and independence, basis and dimension of a linear space, Theory of linear equations, Introduction to n dimensional Euclidian Space.

Inner product, Linear space with inner product, Orthogonalization of vectors, Orthonormal basis of a linear space.

#### Unit II:

Linear transformation, algebra of matrices, partitioned matrices; Statistical applications of the algebra of matrices.

#### Unit III:

Canonical forms, Generalized inverse, Moore – Penrose inverse, Matrix equations.

#### Unit IV:

Quadratic forms, Reduction of quadratic forms, Lagrange's method of transformation of a positive definite quadratic form, Cochran's theorem.

#### Unit V:

Characteristic polynomial, Characteristic roots, Characteristic vectors, Hamilton – Cayley theorem, Spectral decomposition of matrices – symmetric and asymmetric.

**Practicals on the topics :** Solution of linear equations, Orthogonalization of vectors, algebra of matrices, partitioned matrices, Characteristic roots, Characteristic vectors, Hamilton – Cayley theorem.

#### Reading List:

1. Graybill, F.A. (1983): *Matrices with applications in Statistics*, 2<sup>nd</sup> Ed. Wadsworth.
2. Rao, C.R. (1973): *Linear statistical inference and its applications*, 2<sup>nd</sup> ed. John Wiley and Sons, Inc.
3. Searle, S.R. (1982): *Matrix Algebra useful for Statistics*. John Wiley and Sons. Inc.

## SEMESTER-I

Paper: STA 703C

### MEASURE THEORY AND PROBABILITY

Credits: 4 (3+1+0)

#### Part 1: Measure Theory

50

#### Unit I:

Concept of Classes of sets, field, sigma field, minimal sigma field, Borel sigma field, Measure – it's properties with examples, finite and sigma finite measures, Continuity theorem of Measure, Inclusion-Exclusion theorem of Measure, Probability space and conditional probability space, Lebesgue-Stieltjes measure, idea of product space and product measure.

Outer measure, outer measurability, class of outer measurable sets in a Sigma field

**Unit II:**

Construction of outer measure function, Lebesgue measure, Lebesgue Measurable sets, extension of measure on a field, complete measure space.

Measurable transformation and function, random variable, simple and Elementary function, induced measure and distribution function, properties of measurable functions, measurable function as the limit of simple function.

**Reading List:**

1. Basu, A.K.: *Measure Theory and Probability*, Prentice Hall of India.
2. Billingsley, P.: *Probability and Measure*, John Wiley.
3. Halmos, P. R. : *Measure Theory*, Springer.
4. Munroe, M.E. : *Introduction to Measure and Integration*, Addison-Wesley.
5. Rana, I.K.: *An Introduction to Measure and Integration*, Narosa.
6. Kingman J. F. C and Taylor S. J (1966): *Introduction to Measure and Probability*, Cambridge University Press.

**Part 2: Probability****50****Unit I:**

Distribution functions for univariate and multivariate, Expectation and moments, moment inequalities (Markov, Cramer, Holder & Jensen); Characteristic function and properties of characteristic function of a random variables; Inversion Theorem, Uniqueness theorem; Bivariate and multivariate characteristic functions (definition & properties), Convolution theorem.

**Unit II:**

Weak Law of Large Numbers (WLLN) due to Bernoulli, Poisson, Chebyshev and Khintchine; Borel-Cantelli Lemma.

**Unit III:**

Convergence of random variables - Convergence in probability-almost surely, Convergence in mean square and convergence in distribution. Helly's theorem, Helly-Bray Theorem, Continuity theorem of characteristic functions, Slutsky's theorem of convergence.

**Unit IV:**

Central Limit Theorem (CLT) - Lindeberg-Levy, Liapounov and Lindeberg-Feller, Conditional expectation, Basic concept of Martingales (definition and simple problems).

**Unit V:**

Convergence of sequence of random variables, Three series criterion, Kolmogorov's inequality, Basics of Strong Law of Large Numbers (SLLN).

**Reading List:**

1. Bhat B.R, Srivenkataramana T and Pao Madhava K.S. (1997): *Statistics: A Beginner's Text*, Vol. II, New Age International (P) Ltd.
2. Edward P.J, Ford J.S. and Lin (1974): *Probability for Statistical Decision- Making*, Prentice Hall.
3. Goon A.M., Gupta M.K. Dasgupta B. (1999): *Fundamental of Statistics*, Vol. II, World Press, Calcutta.
4. Mood A.M, Graybill F.A and Bose D.C (1974): *introduction to the Theory of Statistics*, McGraw Hill.
5. Feller W: *An Introduction to Probability Theory and Its Applications*, 3<sup>rd</sup> Ed. John Wiley.
6. Coke, Cramer and Clarke: *Basic Statistical Computing*, Chapman and Hall.
7. David, S (1996): *Elementary Probability*, Oxford Press.
8. Hoel P.G (1971): *Introduction to Mathematical Statistics*, Asia Publishing House.
9. Meyer P.L (1970): *Introductory Probability and Statistical Applications*, Addison Wesley.
10. Taha, H. A. (2006): *Operation Research: An Introduction*, Eighth Edition, Prentice Hall.
11. Swarup, K and Gupta, P.K: *Operation Research*, Mac Mohan

# SEMESTER-I

Paper: STA 704C

## LINEAR MODELS AND DESIGN OF EXPERIMENTS-I AND SAMPLE SURVEY-I

Credits: 4 (2+1+1)

### Part 1: Linear Models and Design of Experiments-I

**Linear Model:** Gauss-Markov setup, Normal equations and least square estimator, Error and estimation space, variance and covariance of least square estimates, estimation of error variance, estimation with correlated observations, least square estimates with restriction on parameters.

Tests of hypotheses for one and more than one linear parametric functions, Multiple comparison tests due to Turkey and Scheffe.

**Design of Experiments:** Fixed, mixed and random effects models; Variance components estimation – study of various methods, Tests for variance components.

Analysis of covariance with two concomitant variables

Missing plot technique including general theory and applications (in RBD and LSD)

**Practicals** on the topics : Analysis of covariance, Missing plot technique ( upto 2 missing values )

#### **Reading List:**

1. Das, M.N & Giri, N.C.: *Design and Analysis of Experiments*, New Age International Ltd., 2<sup>nd</sup> ed.
1. Kempthorne: *Design of Experiments*
2. Joshi, D.D : *Linear Estimation and Design of Experiments*, Wiley Eastern Ltd.
3. Parimal Mukhopadhyaya: *Applied Statistics*, New Central Book Agency, Kolkata.
4. Rao, C.R. (1973): *Linear statistical inference and its applications*, 2<sup>nd</sup> ed. John Wiley and Sons, Inc.

### Part 2: Sample Survey I

50

Concepts of population and sample, need for sampling, census and sample surveys.

Basic concepts in sampling and designing of large scale surveys.

Simple random sampling with and without replacement.

Stratified random sampling, estimation with different type of allocation, The construction of strata, Number of strata, Method of collapsed strata, Post stratification.

Sampling with varying probabilities (Unequal probability sampling): PPS with and without replacement methods including Lahiri's scheme.

**Practicals** on the topics : Simple random sampling, Stratified random sampling, PPS sampling.

#### **Reading List:**

1. Sukhatme: *Sampling theory of surveys with application: Indian Society of Agricultural Statistics*.
2. Cochran W.G.: *Sampling Technique* (Third edition): Wiley Eastern.
3. Murthy M.N: *Sampling theory and Methods*: Statistical publishing society Kolkata
4. Des Raj and Chandok: *Sampling design*: Jata McGraw Hill
5. Singh D. and Choudhury F.S.: *Theory and Analysis of Sample Survey Design*: New Age International Publishers.
6. Mukhopadhyay, Parimal : *Theory and Methods of Survey Sampling*.

## SEMESTER-I

Paper: STA 705E

### QUANTITATIVE TECHNIQUES IN STATISTICAL ANALYSIS

Credits: 3 (2+1+0)

**Analysis of quantitative data:** Concept of central tendency, dispersion, moments, skewness and kurtosis.

**Bivariate data:** Scatter diagram, Product moment correlation, Multiple and Partial correlation, Linear regression, Coefficient of determination, Fitting of linear regression, Fitting of curves reducible to polynomials by transformation. Rank correlation, Spearman's and Kendall's measures, Theory of attributes - Measures of association.

**Sample survey:** Definition of related terms with example from different fields of study, Principles of sample survey, Different steps in a large scale sample survey, size of sample, Judgement and random sampling with examples. Concept of different sampling techniques, namely, Simple random sampling with and without replacement, Stratified random sampling, Systematic sampling, Multistage sampling, Cluster sampling, Double sampling, Probability proportional to size sampling – with examples (derivation of different estimates are not required).

**Testing of Hypothesis:** Parameter and statistic, Sampling distribution, Standard error, Concept of hypothesis, Type I and Type II errors, Level of significance, Applications of Chi-square, t and F statistics, Large sample tests and Confidence interval.

**Analysis of Variance:** Concept of Analysis of Variance (ANOVA), Assumptions and effects of violation of the assumptions., Concept of Fixed effects and Mixed linear models, ANOVA for one way and two way classified data with  $m (\geq 1)$  observations per cell (for fixed effects only).

#### References:

2. Das, M.N & Giri, N.C.: *Design and Analysis of Experiments*, New Age International Ltd., 2<sup>nd</sup> ed.
3. Parimal Mukhopadhyaya: *Applied Statistics*, New Central Book Agency, Kolkata.
4. Goon A.M., Gupta M.K. Dasgupta B. (1999): *Fundamental of Statistics*, Vol. II, World Press, Calcutta.
5. Gupta, S.C and Kapoor, V.K.: *Fundamentals of Applied Statistics*, S. Chand & Sons, 4<sup>th</sup> edition.

## SEMESTER-II

Paper: STA 801C

### DISTRIBUTION THEORY

Credits: 4 (3+1+0)

#### Unit I:

Basic tools of distribution theory: Joint, marginal and conditional probability mass functions (p.m.f.) and probability density functions (p.d.f.); Moments (raw, central, and factorial) in terms of Stirling numbers; Functions of random variables and their distributions using Jacobian of transformation and other tools.

#### Unit II:

Basic distributions: Logarithmic, positive and negative multinomial, bivariate normal, bivariate exponential and multivariate normal distributions, Probability distributions of extremes and its asymptotic distributions.

**Unit III:**

Censoring, Truncation and weighted distributions (use 10 types of weight functions). Truncated Binomial, Poisson, Logarithmic, Normal, Cauchy distributions. Intervened Poisson distributions. Mixture distributions: Definition, finite mixtures, Zero modified distributions with examples, Mixed Poisson distributions and its properties and examples of Poisson mixtures, Mixtures of Binomial distributions with examples.

**Unit IV:**

Sampling distributions: Non-central chi-square, t, and F distributions their properties and their related distributions.

**Unit V:**

Order statistics - their distributions and properties; Joint and marginal distributions of order statistics (discrete and continuous).

**Reading List:**

1. Dudewicz, E.J. and Mishra, S.N. (1988): *Modern Mathematical Statistics*, Wiley, Int'l Students' Edition.
2. Rohatgi, V.K. (1984): *An Introduction to Probability Theory and Mathematical Statistics*, Wiley Eastern.
3. Rao, C.R. (1973): *Linear Statistical Inference and Its Applications*, 2/e, Wiley Eastern.
4. Johnson, N.L., Kemp, and Kotz, S. (2005): *Univariate Discrete Distributions*, Wiley, 3<sup>rd</sup> Ed.
5. Johnson, N.L., Kotz, S. and Balakrishnan, (2004): *Univariate Continuous Distributions*, Wiley, 2<sup>nd</sup> Ed., Vol. 1 & vol. 2.
6. Johnson, N.L., Kotz, S. and Balakrishnan, (2004): *Multivariate Discrete Distributions*, Wiley, 2<sup>nd</sup> Ed.

**SEMESTER-II****Paper: STA 802C****STATISTICAL INFERENCE-1 (POINT AND INTERVAL ESTIMATION)****Credits: 4 (2+1+1)****Unit I:**

Concept of point estimation. Properties of point estimators: (i) Unbiasedness (ii) Sufficiency (iii) Completeness (iv) UR.VUE and related theorems including Rao-Blackwell theorem, Lehmann Scheffe thorem. (v) Invariance of estimators, Pitman estimator.

**Unit II:**

Bounds for variance of Estimators: (i) Rao-Cramer Lower bound (ii) Rao-Cramer inequality for multi parameter case (iii) Bhattacharyya bound (iv) Chapman Robins-Kiefer Lower bound.

**Unit III:**

Method of estimation: (i) Maximum likelihood and properties (ii) Method of moments (iii) Minimum chi square (iv) Method of minimum distance

**Unit IV:**

Interval estimation: (i) Sampling from normal population (ii) Pivotal quantity method (iii) Statistical method.

**Unit V:**

Large sample theory: (i) Consistency (ii) BAN (iii) CANE and related theorems (iv) Large sample properties



of MLE, MME and Minimum chi-square and related theorems.

**Practicals** on the topics : Methods of estimation - (i) Maximum likelihood and properties (ii) Method of moments (iii) Minimum chi square, Interval estimation.

**Reading List:**

1. Kale B. K. (1999): *A First Course on Parametric Inference*
2. Rohatgi V. (1988): *An Introduction to Probability and Mathematical Statistics*, Wiley Eastern Limited. New Delhi, (Student Edition)
3. Rao, C. R. (1973): *Linear Statistical Inference and Its Application*, 2/e Wiley Eastern
4. Lehman: *Theory of Point Estimation*.
5. Goon, Gupta & Dasgupta: *An Outline of Statistical Theory* (Vol 2). World Press.
6. Saxena & Surindam : *Statistical Inference*

## SEMESTER-II

Paper: STA803C

### LINEAR MODELS AND DESIGN OF EXPERIMENTS-II AND SAMPLE SURVEY-II

Credits: 4 (2+1+1)

#### Part 1: Design of Experiments-II

50

General factorial experiments, factorial effects, best estimates and testing the significance of factorial effects  $2^n$  ( $n=4,5,6$ ) and  $3^n$  ( $n=2,3$ ) factorial experiments, Complete and partial confounding, Split plot design, Fractional replication.

Incomplete block designs (IBD)- Introduction and properties; Orthogonal Latin Squares – definition and construction, Balanced Incomplete Block Design (BIBD), Idea of General Block design, Construction of BIBD, Partially Balanced Incomplete Block Design (PBIBD) with 2 associated classes, Lattice designs, Youden square design.

Response surface designs: first and second order, Introduction to Bio-assay.

**Practicals** on the topics : Factorial experiments ( $2^n$  ( $n=4,5$ ) and  $3^n$  ( $n=2$ )), Confounding, Split plot design, BIBD, PBIBD.

**Reading List:**

6. Das, M.N & Giri, N.C.: *Design and Analysis of Experiments*, New Age International Ltd., 2<sup>nd</sup> ed.
5. Kempthorne: *Design of Experiments*
6. Joshi, D.D : *Linear Estimation and Design of Experiments*, Wiley Eastern Ltd.
7. Parimal Mukhopadhaya: *Applied Statistics*, New Central Book Agency, Kolkata.
8. Rao, C.R. (1973): *Linear statistical inference and its applications*, 2<sup>nd</sup> ed. John Wiley and Sons, Inc.

#### Part 2: Sample Survey-II

50

Sampling with varying probabilities (Unequal probability sampling): Related estimators of a finite population mean (Horvitz-Thompson, Yates and Grundy estimator, Hansen-Hurwitz and Des Raj estimators for general sample size, Murthy's estimator for a sample of size 2)

Systematic sampling, Comparison of Systematic sampling with Stratified and Simple random sampling

without replacement, Systematic sampling for population with linear trend, periodic variation and auto correlated population.

Ratio method of Estimation, Combined ratio estimator. Regression method of Estimation including its optimum property.

Cluster sampling, Multi-stage sampling: Two-stage sampling, Idea of Quota sampling, Double sampling.

Non sampling errors, Idea of small area sampling.

**Practicals** on the topics : Sampling with varying probabilities - Horvitz-Thompson, Des Raj and Murthy's estimators, Systematic sampling, Ratio method of Estimation, Combined ratio estimator. Regression method of Estimation, Cluster sampling, Two-stage sampling.

**Reading List:**

1. Sukhatme: *Sampling theory of surveys with application*, Indian Society of Agricultural Statistics.
2. Cochran W.G.: *Sampling Technique* (Third edition), Wiley Eastern.
3. Murthy MN: *Sampling theory and Methods*, Statistical publishing society Kolkata
4. Des Raj and Chandok: *Sampling design*, Tata McGraw Hill
5. Singh D. and Choudhury F.S.: *Theory and Analysis of Sample Survey Design*, New Age International Publishers.
6. Mukhopadhyay, Parimal : *Theory and Methods of Survey Sampling*.
7. Rao, J.N.K. (2003): *Small Area Sampling*, Wiley.

## SEMESTER-II

Paper: STA804C

### SIMULATION, LPP & COMPUTER PROGRAMMING IN C

Credits: 4 (2+1+1)

**Unit 1: Simulation:**

**20**

Introduction, Definition, Advantages, Disadvantages and Applications of Simulation, Steps in a Simulation procedure, Monte Carlo method.

Generation of random numbers using congruence method, Generation of random variables using Inverse transform method and Acceptance-rejection method, Idea of evaluation of integrals using random numbers by Monte Carlo approach for single and multiple integrals, Markov Chain Monte Carlo (MCMC).

**Unit 2: Linear Programming Problem and its applications:**

**40**

The general linear programming problem, Properties of the solutions to a linear programming problem.

Generation of extreme points development for an optimum feasible solution, the simplex algorithm, the artificial variable technique, the two – phase algorithm.

Duality in linear programming, the symmetric and asymmetric duals.

Application of linear programming, the assignment problem, the transportation problem.

**Unit 3: Computer Programming in C**

**40**

Algorithms, Flowcharts; Compilers, High level language; Basics of Programming; Representation of integer and floating point numbers (Recap).

Programming in C: Basic element of program; Modules of Functions; Arithmetic operators; Precedence rules; Different data types-Integer, floating point, double precision and character; Constants and Variables; Formatted input & output; Relational and Logical operations; IF-ELSE statement, WHILE statement; FOR statement, DO statement, nesting; Arrays; Idea of String; Built-in and concept of user defined functions and structure with simple examples.

**\*\* proficiency in writing programs for determination of commonly used statistical measures and carrying out statistical analysis is to be stressed upon**

**Practicals on the topics :**

Simulation : Generation of random numbers using congruence method, Generation of random variables using Inverse transform method.

Linear Programming Problem and its applications : simplex method, artificial variable technique and two – phase algorithm. Application of linear programming, the assignment problem, the transportation problem.

**References:**

1. Hillier, F. S. and Lieberman, G.J. (2001): *Introduction to Operation Research*, 7<sup>th</sup> Edition, Irwin.
2. Taha, H. A. (2006): *Operation Research: An Introduction*, Eighth Edition, Prentice Hall.
3. Sharma, S. D. (2002): *Introduction to Operation Research*, thirteenth Edition, Kedar Nath and Ram Nath & Co.
4. Bronson, G. J., Menconij.: *A First Book of C: Fundamentals of C Programming*, Jaico Publishing House.
5. Emmett Beam,J :*Illustrated C Programming*, BPB Publications
6. Kanetkar, Y. : *Let us C*, BPB Publications

**SEMESTER-II**

**Paper: STA805E**

**DEMOGRAPHY AND ACTUARIAL STATISTICS**

**Credits: 3 (2+1+0)**

Unit 1: Mortality rates - CDR, SDR, STDR, IMR along with their merits and demerits

Unit 2: Life Tables- Construction of a complete life table along with assumptions and uses, construction of an abridged life table, multiple decrement tables.

Unit 3: Stable and Stationary population, population projection.

Unit 4: Introduction to Insurance systems.

Risk Theory: Utility theory and the economics of insurance, individual risk models for a short term, common loss distributions. Collective risk models for a single period and for an extended period, ruin theory, applications.

Unit 5: Mortality estimation: exposure to risk, approximation for incomplete data.

Unit 6: Smoothing/graduation: Parametric, tabular and graphical methods, tests of graduation.

Unit 7: Actuarial Statistics: Life insurance, life annuities, net premiums, net premium reserves, mortality profit/loss and Theiele's equation.

## SEMESTER-III

Paper: STA901C

### MULTIVARIATE ANALYSIS-I & REGRESSION ANALYSIS

Credits: 4 (2+1+1)

#### **Part 1: Multivariate Analysis-I**

50

Unit 1:

18

Multivariate normal distribution, Transformation of variables, Random sampling from a multivariate normal distribution, Maximum likelihood estimators of parameters, Distribution of sample mean vector, Inference concerning the mean vector when the covariance matrix is known, Multivariate Central Limit Theorem.

Unit 2:

16

Wishart matrix - its distribution and properties, Distribution of sample generalized variance; Distribution of simple, partial and multiple correlation coefficient.

Unit 3:

16

Null distribution of Hotelling's  $T^2$  statistic. Application in tests on mean vector for one or more multivariate normal populations. Mahalanobis  $D^2$ , Likelihood Ratio test criteria for testing equality of mean vector (one and more than one sample problems).

**Practicals on the topics :** Simple, partial and multiple correlation coefficient, Hotelling's  $T^2$  statistic, Mahalanobis  $D^2$  statistic.

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

1. Anderson, T. W. (1983): *An Introduction to Multivariate Statistical Analysis*, John Wiley.
2. Giri, N. C. (1977): *Multivariate Statistical inference*, Academic Press.
3. Kshirsager A.M. (1972): *Multivariate Analysis*, Marcel Dekker
4. Rao, C. R. (1972): *Linear Statistical inference and its Application*, John Wiley.
5. Srivastava & Khatri (1979): *An introduction to Multivariate Statistics*, North-Holland.
6. Johnson & Wichern (1992): *Applied Multivariate Statistical Analysis*, Prentice Hall
7. Chakravarti, Lahe & Roy: *A Hand Book of Methods of Applied Statistics , Vol 1*, John Wiley

#### **Part 2: Regression Analysis**

50

Unit 1:

Multiple Regression: Univariate & Multivariate; Hypothesis Testing in multiple linear regression; Regression without intercept terms, use of  $R^2$  &  $R^2$  adjusted; Residual Analysis plots;

Unit 2:

Computational techniques for variable selection (without derivation), Stepwise regression, Mallows  $C_p$  statistic - purpose & use.

Multicollinearity – effects, detection and remedies; Autocorrelation: consequences and tests.

Logistic regression: models, examples, MLE of parameters, iterative procedure to solve likelihood equations.

**Practicals on the topics :** Univariate & Multivariate regression, Hypothesis Testing in multiple linear regression.

**References:**

1. Montgomery, Douglas C. E., Peck, A and Vining, G. Geoffrey: *Introduction to Linear Regression Analysis*.
2. Johnston: *Econometrics*.

**SEMESTER-III****Paper: STA902C****INFERENCE-II (TESTING OF HYPOTHESIS)****Credits: 4 (2+1+1)****Unit 1:**

Basic concepts: critical region, power function, randomised and non-randomised tests; Neyman-Pearson Fundamental Lemma and Generalisation, MP and UMP tests, Neyman-Pearson theorem; Consistency, monotonicity and invariance principle of tests and their construction.

**Unit 2:**

UMPU- tests, Type A and Type  $A_1$  critical regions, Optimum Region and Sufficient statistic, Similar Regions.

**Unit 3:**

Likelihood Ratio Tests, Asymptotic distribution of Likelihood ratio.  
Randomised test: Test function, Neyman-Pearson theorem, Monotone Likelihood Ratio.

**Unit 4:**

Sequential Analysis: Wald's Sequential Probability Ratio Test (SPRT), Properties of SPRT, Efficiency of SPRT, The Fundamental Identity of Sequential Analysis, OC Function, ASN.

**Practicals on the topics :** Power curves of different distributions – Binomial, Poisson, Normal, Exponential.

**References:**

1. George Cassella & Roger L. Berger (1994): *Statistical Inference*. Wadsworth & Brooks, California.
2. Parimal Mukhopadhyay (1996): *Mathematical Statistics*. New Central Book Agency, Kolkata.
3. C. R. Rao (1974): *Linear Statistical Inference and its Applications*. Wiley Eastern Private Limited, New Delhi.
4. Lehman, E. L. (1959): *Testing Statistical Hypotheses*. John Wiley.
5. Kendal, M. G. & Stuart, A (1960): *The Advanced Theory of Statistics*. Vol 2. Charles Griffin, London.
6. Goon, A. M., Gupta, M. K., and Dasgupta (1987): *An Outline of Statistical Theory*. Vol.-II, World Press.

## SEMESTER-III

Paper: STA903C

### DEMOGRAPHY & STOCHASTIC PROCESSES

Credits: 4 (3+1+0)

#### Part 1: Demography

50

Unit 1:

Demographic transition theory Idea of recent census, SRS, NFHS (for India and Assam)  
Coverage and content errors in demographic data, Use of balancing equations and Chandra Sekharan Deming formula, Adjustment of age data use of Whipple, Myer indices.

Unit 2:

Life tables and its application Methods of construction of abridged life table (Greville and Chiang methods) Gompertz, Makeham curve. Fertility measures from cohort data. Stochastic modules for reproduction.

Unit 3:

Stable population model, Population projection (component methods and Idea of Leslie matrix)

Unit 4:

Migration: Basic concept and Estimation, National Population Policy.

#### **References:**

1. Swason et al : *Methods and Materials of Demography*.
2. Chiang (1968): *Introduction to Stochastic Processes in Bio Statistics*, John Wiley
3. Keyfitz N. (1977): *Applied Mathematical Demography*, Springer Verlag.

#### Part 2: Stochastic Processes

50

Stochastic Process: Concept and definition, Specification of Stochastic process, Stationary Processes.

Markov Chain: Definition, Transition Probabilities, Idea of Order of a Markov Chain, Higher transition probabilities (Chapman-Kolmogorov equation) , Generalization of independent Bernoulli trials, Sequence of chain dependent trials, Classification of states and chains, Stability of Markov System, Graph theoretic approach, Markov chain with Denumerable number of states.  
Random walk and Gambler's Ruin problem.

Poisson Process, Postulates and Properties of Poisson Process, Pure Birth process, Birth-death process.

#### **References:**

1. Adke, S. R and Manjunath S. M (1984) : *An Introduction to Finite Markov Processes*.
2. Bhat B. R (2000): *Stochastic Models: Analysis and Applications*, New Age International India.
3. Cinler, E (1975): *Introduction to Stochastic Processes*, Prentice Hall.
4. Hoel, P.G, Port,S.C, Stone, C.J (1972): *Introduction to Stochastic Processes*, Houghton Mifflin and Co.
5. Medhi, J (1982): *Stochastic Processes*, Wiley Eastern.
6. Ross: *Stochastic Process*, John Wiley.
7. Bailey, N.T.J. (1964): *Elements of stochastic process with applications to the natural sciences*, Wiley.

**SEMESTER-III**  
**Paper: STA904C**  
**Special Papers (Any one)**

**Paper: STA904C (A)**  
**ACTUARIAL STUDIES –I**  
**Credits: 4 (3+1+0)**

Introduction to insurance systems.

Risk theory: Utility theory and the economics of insurance, individual risk models for a short term, common loss distributions. Collective risk models for a single period and for an extended period, ruin theory, applications.

Mortality and Life Tables: Survival models, life tables.

Multiple decrement tables.

Stationary Population.

Mortality estimation: exposure to risk, approximation for incomplete data.

Smoothing /graduation: Parametric, tabular and graphical methods, tests of graduation.

**References:**

1. Bowers et al. (1997): *Actuarial Mathematics*. Second Edition. Society of Actuaries.
2. Rob Kaas Marc Goovaerts, Jan Dhaene and Michel Denuit (2008): *Modern Actuarial Risk Theory* using R, Springer.
3. Slud, E.V. (2001): *Actuarial Mathematics and Life-Table Statistics*, University of Maryland, USA.

**Paper: STA904C (B)**  
**BIO-STATISTICS-I**  
**Credits: 4 (3+1+0)**

**Part1: Demography**

**50**

Basic idea, Demographic transition theory, Evaluation and adjustment of age data, indexes of age preference: Whipple's index, Myre's index, smoothing of age data, construction of complete and abridged life table by Chiang's methods, life table from the perspective of Markov chain, Multiple decrement life table, - cause specific life table, multistage life table, health expectancy, Statistical theory of life table, Competing risk, structure of population, Mathematical models in fertility and Human reproduction, population projection by the matrix method.

**References:**

1. Stockwel & Saigel: *The methods and materials of Demography*.
2. Chiang, C.L. : *The life table and its applications*
3. Namboodiri and Suchindran: *Life tables and their applications*
4. Ramkumar : *Technical Demography*

**Part2: Epidemiology**

**50**

Introduction: Definition and Scope of epidemiology.

Measuring health and disease: Definitions of health and disease, measures of disease frequency, Comparing disease occurrence.

Type of Study: Observational epidemiology, Experimental epidemiology, potential errors in epidemiological studies.

Causation in Epidemiology. Epidemiology and prevention: The scope of prevention, levels of prevention, Screening.

Communicable disease epidemiology: epidemic and endemic disease, chain of infection.

Clinical epidemiology: Definitions of normality and abnormality, diagnostic tests, Effectiveness of treatment, prevention in clinical practice.

Environmental and occupational epidemiology, Public health surveillance, Epidemiology, health services and health policy.

Epidemic processes: Simple and General. Chain binomial models

**References:**

1. R. Beaglehole, R. Bonita and T. Kjellstrom (1993): *Basic Epidemiology*, WHO.
2. Principles of Epidemiology. Self \_study Course. U. S. Department of Health and Human Services. 1992
3. Bailey, NTJ (1990): *The Elements of Stochastic Processes*, John Wiley and Sons.

**Paper: STA904C (C)**  
**OPERATIONS RESEARCH - I**  
**Credits: 4 (3+1+0)**

**Introduction to Operations Research: 10**

Definition and scope of Operations Research (OR), phases in Operations Research, different types of models and their uses, general method for solving OR models.

**Queuing Theory: 45**

General concept: Basic Characteristics of a Queue, Notations, Transient and Steady state, Little's formula (without proof).

Steady state distribution and waiting time distribution of M/M/1 and M/M/c models;

Steady state distribution of M/M/1/k, M/M/c/c and M/M/c//m ( $m > c$ ).

(Models are to be discussed with numerical examples)

Idea of the following models: M/E<sub>k</sub>/1, M/G/1, GI/M/1, M/D/1 and M/D/c (derivation of the associated distributions are not required). Idea of Bulk queues.

**Inventory Management: 25**

Inventory control – definition, Variables in Inventory problems, Characteristics of Inventory system, Classification of Inventory models, Deterministic Inventory models – Concept of Economic Ordering Quantity (EOQ), Static demand models, EOQ model without shortage – The Economic Lot Size with uniform demand, The Economic Lot Size with different rates of demand in different cycles, The Economic Lot Size with finite rate of replenishment; EOQ model without shortage – The EOQ with constant rate of demand and constant scheduling time, The EOQ with constant rate of demand and variable scheduling time, The Production Lot Size model with shortages.

**Resource Analysis and Time Estimate in Network Scheduling: 20**

Different time estimates related to any project under CPM and PERT, Probability distribution associated with PERT, Probability of achieving completion date of project, Resource allocation – Resource Smoothing and Resource Leveling.

**References :**

1. Hillier, F. S. and Lieberman, G.J. (2001): *Introduction to Operation Research*, 7<sup>th</sup> Edition, Irwin.



2. Gross, D., Shortle, J. F., Thomson, J. M. and Harris, C. M. (2008): *Fundamentals of Queueing Theory*, John Wiley & Sons.
3. Waters, Donald and Waters, C. D. J. (2003): *Inventory Control and Management*, John Wiley & Sons.
4. Taha, H. A. (2006): *Operation Research: An Introduction*, Eighth Edition, Prentice Hall.
5. Srinath, L. S. (1996): *PERT and CPM – Principles and Applications*, Third Edition, East West Press
6. Sharma, S. D. (2002): *Introduction to Operation Research*, thirteenth Edition, Kedar Nath and Ram Nath & Co.

**Paper: STA904C (D)**  
**SURVIVAL ANALYSIS -I**  
**Credits: 4 (3+1+0)**

Unit 1:

Concept of time, Order and random censoring, likelihood in these cases, Life distribution-Exponential, Gamma, Weibull, Lognormal, Pareto, Linear Failure rate, Parametric inference (point estimation, confidence intervals, scores, LR MLE tests (Rao-Wilks-Wald) for these distribution.

Unit 2:

Life tables, Failure rate mean residual life and their elementary properties. Ageing classes and their properties. Bath tub Failure rate.

Unit 3:

Estimation of survival function- Actuarial estimator, Kaplan-Meier Estimator, Estimation under the assumption of IFR/DFE.

**References:**

1. Cox D. R. And Oakes (1984): *Survival Analysis*, Chapman and Hall. New York
2. Gross A. J. and Clark V. A. (1975): *Survival distribution: Reliability applications in Biomedical sciences*. John Wiley and Sons.
3. Elandt- Johnson, R. E. Johnson N.L.: *Survival models and Data Analysis*, John Wiley and sons.
4. Miller- R.G.(1981): *Survival Analysis*.
5. Kalbfleisen, John Wiley, J. D. and Prentice R.T (1980): *The statistical Analysis of failure Data*, John Wiley.

**Paper: STA904C (E)**  
**DEMOGRAPHY I**  
**Credits: 4 (3+1+0)**

Unit 1:

Demographic Transition Theory: Evaluation and Adjustment of Age data, Digit Preference – Whipple's index, Meyer's index, blended method, Age and sex Ratio analysis, Chandrasekhar Deming Method. Method of Smoothing.

Unit 2:

Infant mortality, Adjusted infant mortality rates, Life Tables: Construction by Chiang's method, Life table from the prospective of Markov chain Distribution of life table functions and their estimation, Multiple decrement life table with special reference to cause specific life table, Competing risks, Idea of healthy life expectancy.

Unit 3:

Estimation of fertility rates by indirect methods, Stochastic models for reproductive distribution of time to

first birth, inter live birth intervals and number of births, estimation of parameters Shep's model.

Unit 4:

Population projection by matrix method. Detailed discussion on Lesic matrix. Evaluation of projection, Idea of projecting socio-economic characteristics.

**References:**

1. Shryock, H. S, Seigal, J. S and Associates (1997): *Methods and Materials of Demography*, Academic Press Inc., London
2. Chiang, C. L (1968): *Introduction to Stochastic Process in Biostatistics*, John Wiley
3. Keyfitz, N (1977): *Applied Mathematical Statistics*, Springer Verlag.
4. Cox P. R (1970): *Demography*, Cambridge University Press
5. Spiegelman, M (1969): *Introduction to Demographic Analysis*, Harvard University Press.

**Paper: STA904C (F)**  
**ASTRO STATISTICS-I**  
**Credits: 4 (3+1+0)**

Linear least squares, matrix problem, Singular value decomposition of a matrix, Non linear least squares, Relative distance between distributions, Noisy channel.

Estimation of Gaussian Distributions through least square estimates as well as through maximum likelihood estimates. Some extreme value distributions and their properties.

Shannon information content of an outcome. Entropy of an ensemble, Redundancy of X, joint entropy of X and Y, decomposition of entropy. Relative entropy of Kullback-Leibler divergence. Gibbs inequality.

**References:**

1. G.Beutler, L.Mervert & A.Verdun : *Methods of Celestial Mechanics ; Vol I & II :*
2. S.M.Miyama, K.Tomisaka & T Hanawa: *Numerical Astrophysics*
3. P.Hellings : *Astrophysics with a PC : An Introduction to Computational Astrophysics :*
4. P.N.Tan, M.Steinbach & V.Kumar : *Introduction to Data Mining*
5. J.G.Babu & E.D.Fiegelson : *Astrostatistics*

**SEMESTER-III**  
**Paper: STA905E**

**OFFICIAL STATISTICS AND STATISTICS FOR NATIONAL DEVELOPMENT**  
**Credits: 3 (2+1+0)**

Unit-1:

**35**

**Official Statistics:** Study of Population Census in India, Highlights of the last two censuses; Functions of National Sample Survey Organization (NSSO), Central Statistical organization (CSO) and National Statistical Commission (NSC).

Unit-2:

**25**

Economic Development: Estimation of National Income (Product approach, income approach,

expenditure approach); Pareto's law of income distribution, log normal distribution, income inequality; Measuring inequality in incomes: Lorenz Curve, Gini's coefficient.

Unit 3: **20**  
Human Development: Indicators of Human Development, Major problems of Human Resource Development; Human Development Index (HDI) and its variants, Gender Inequality in Human Resource Development - Exploration, Measurement and Incidence of Gender Inequality, Concept of Human Poverty Index (HPI).

Unit 4: **20**  
Human Resources and economic development of India: Introduction, demographic features of India's population, an overview of the population policies of India.

**References:**

1. CSO (1980): *National Accounts Statistics-Sources and Health*
2. Keyfitz N: *Applied Mathematical Demography*, Springer Verlag
3. Sen, A. (1997): *Poverty and Inequality*
4. Bhende A and Kanitkar R: *Principles of Population Studies*
5. UNESCO: *Principles for Vital Statistics Systems Series M-12*
6. UNDP Human Development Reports, Oxford University Press
7. Asian Development Bank: Asian Development Outlook.
8. Hans Raj (2009): *Fundamentals of demography, population studies with special reference to India*, Surjit Publications, Delhi, India.
9. Sinha, V.C. and Zacharia, E.(2007): *Elements of Demography*, Allied Publishers Private Ltd., India.
10. Census Reports of India (upto 2011)
11. Economic Census, All India Reports, 2005 and 2013.
12. Population Policy of India, 2000.

## **SEMESTER-IV**

**Paper: STA1001C**

### **NON PARAMETRIC STATISTICAL INFERENCE AND BAYESIAN INFERENCE**

**Credits: 4 (2+1+1)**

**Part 1: Non Parametric Statistical Inference** **50**

Tests Based on Runs: Idea, Different lemmas, Expectation and Variance of Runs, Tests based on the length of longest run.

Tests of goodness of fit: The Chi-Square test, The Empirical distribution function, related theorems and corollaries; The Kolmogorov-Smirnov (KS) one sample test, related theorems and applications.

One sample and paired sample techniques: The Ordinary Sign test and The Wilcoxon Signed-rank test.

The General two sample problem: The Wald-Wolfowitz Run test, The K.S two sample test, Man-Whitney U test.

Linear Rank statistics and its distributional Properties.

Idea of Wilcoxon test and Kruskal – Wallis one way ANOVA test.

**Practicals** on the topics: Run test, Kolmogorov-Smirnov test, Sign test, Wilcoxon Signed-rank test, Wald-

Wolfowitz Run test, Kolmogorov-Smirnov two sample test, Man-Whitney U test.

**References:**

1. Gibbons J.D (1985): *Non Parametric Statistical Inference* 2<sup>nd</sup> Ed. Marcel Dekker Inc.
2. Mukhopadhyay P (1996) *Mathematical Statistics* New central Book Agency (Kolkata)
3. Seigel sidney : *Non Parametric Statistics for Behavioural Science* Mc. Graw Hill.

**Part 2: Bayesian Inference**

50

Unit 1:

Elements of Decision Theory: Introduction, Basic Concepts, Bayes and Minimax Decision rules. Different types of loss function, Estimation of Parameters: Bayes estimate and Minimax estimate with examples, Point estimation, Interval estimation and Testing of Hypothesis as Decision Problems.

Unit 2:

Subjective and Frequentist Probability, Advantages of Bayesian Bayes theorem, Subjective prior distribution of a parameter, Computation of posterior distribution, Natural Conjugate family of priors for a model, Hyper parameters of a prior form conjugate family, Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension, Non informative, improper and invariant priors, Jeffrey's invariant prior, Bayesian point estimation- as a prediction problem from posterior distribution, Bayes estimators for (i) absolute error loss, (ii) squared error loss, and (iii) 0-1 loss.

Unit 3:

Bayesian interval estimation: Credible intervals, High posterior density regions; Bayesian testing of Hypothesis: Specification of the appropriate form of the prior distribution for a Bayesian testing of hypothesis problem; Bayesian Computation: Analytic approach, E-M algorithm, MCMC, Gibbs sampling.

**References:**

1. AM Goon, MK Gupta, B Dasgupta: *An outline of Statistical Theory* Vol.II:. World Press.
2. Parimal Mukhopadhyay: *Mathematical Statistics*: New Central Book Agency
3. JO Berger : *Statistical Decision Theory and Bayesian Analysis*, Springer Verlag
4. A K Bansal : *Bayesian Parametric Inference*, Narosa Publishing House
5. J K Ghosh, M Delampady and T. Samanta: *An Introduction to Bayesian Analysis Theory and Methods*.
6. Peter Lee. Arnold: *Bayesian Statistics: An Introduction*. London.

## SEMESTER-IV

Paper: STA1002C

### MULTIVARIATE ANALYSIS – II & ELEMENTARY DATA MINING

Credits: 4 (2+1+1)

**Part 1: Multivariate Analysis – II**

70

Unit 1:

Distribution of the matrix of sample regression coefficients and the matrix of residual sum of squares and cross products, Rao's U-statistic, its distribution and applications, Multivariate analysis of variance (MANOVA) of one and two way classified data.

Unit 2:

Classification and discrimination procedures for discrimination between two multivariate normal

populations - sample discriminant function, tests associated with discriminant functions, probabilities of misclassification and their estimation, Classification into more than two multivariate normal populations.

Unit 3:

Principal component, Dimension reduction, Canonical variables and Canonical correlation – definition, use, estimation and computation; Factor Analysis.

**Practicals** on the topics: Canonical correlation, Discriminant analysis, Principal component, Factor Analysis.

**References:**

1. Anderson, T. W. (1983): *An Introduction to Multivariate Statistical Analysis*, John Wiley.
2. Giri, N. C. (1977): *Multivariate Statistical inference*, Academic Press.
3. Kshirsager A.M. (1972): *Multivariate Analysis*, Marcel Dekker
4. Rao, C. R. (1972): *Linear Statistical inference and its Application*, John Wiley.
5. Srivastava & Khatri (1979): *An introduction to Multivariate Statistics*, North-Holland.
6. Johnson & Wichern (1992): *Applied Multivariate Statistical Analysis*, Prectice Hall
7. Chakravarti, Lahe & Roy: *A Hand Book of Methods of Applied Statistics , Vol 1*, John Wiley

## **Part 2: Elementary Data Mining**

**30**

Introduction to Data Mining and Knowledge Discovery in Databases, Global models and local patterns in databases, Measurement and its types, distance measures, data transformation and data quality, Data visualization- single variable, between two variables, more than two variables.

**References:**

1. Pai J, Han J and Kamber M. (2011): *Data Mining: Concepts and Techniques* (Third edition), Elsevier.
2. Hand D, Mannila H. and Smyth P. (2001): *Principles of Data Mining*, Prentice-Hall of India pvt. Ltd.
3. Maimon O and Rokach L. (2010): *Data Mining and Knowledge Discovery Handbook*, Second Edition, Springer.

## **SEMESTER-IV**

**Paper: STA1003C**

### **TIME SERIES & ECONOMETRICS**

**Credits: 4 (2+1+1)**

#### **Part 1: Time Series**

**50**

Unit 1:

Introduction to Time Series, Decomposition of Time Series, Determination of Trend, Seasonal and Cyclical components of Time Series, Variate Difference method, Periodogram and Correlogram analysis.

Unit 2:

Discrete parametric stochastic processes, Introduction to Stationary processes, Auto-covariance, Auto-correlation and Auto-regressive process, Properties of Auto-covariance function, Concept of Weak Stationarity, Moving Average (MA), Linear processes.

Unit 3:

ARMA Models: Introduction to ARMA processes, ARMA (p,q) processes, The auto-correlation function and

partial auto-correlation function of an ARMA (p,q) process, Forecasting ARMA processes.

Unit 4:

Spectral Analysis: Spectral densities of MA, AR, ARMA.

**Practicals** on the topics: Trend fitting by Moving Average method, Variate Difference method, Spencer's 15 point, 21 point formulae, Fitting of Auto-regressive series of order 1 and 2, Correlogram, Power Spectrum.

**References:**

1. Anderson, T.W. (1971): *Statistical Analysis of Time Series*, Wiley, NY
2. Box, G.E.P and Jenkins, G.M.(1976): *Time series Analysis-Forecasting and Control*, Holden-day, San Francisco.
3. Brockwell, P.J. and Davis, R.A.(1996): *Introduction to Time Series and Forecasting*, Springer, New York.
4. Medhi, J. (2009): *Stochastic Processes*, 3<sup>rd</sup> Ed., New Age International Publishers, New Delhi, India.

**Part 2: Econometrics**

**50**

Unit 1:

Nature of econometrics. The two-variable linear model, least square (LS) estimators, properties of LS estimators, Inference in the LS method.

Unit 2:

The k-variable linear model, Assumptions, Ordinary least square (OLS) estimators, Inference in the OLS method, Tests of structural change.

Unit 3:

Heteroscedasticity, Auto correlation and Multicollinearity: implication and consequences, tests and solutions.

Unit 4:

Concept of Distributed Lag Models: Finite and Infinite, Idea of Serial Correlation and Seasonality in distributed lag models.

Unit 5:

Simultaneous equation model: Introduction, Structural and Reduced forms, Identification – rank and order conditions, Estimation: Indirect least squares method, Two-stage least squares method, Least variance ratio method.

**Practicals** on the topics : Ordinary least square (OLS) estimators, Tests of structural change, Auto correlation and Multicollinearity.

**References:**

1. Johnston J : *Econometric methods*, Third edition, Mc Graw Hill
2. Gujarathi : *Basic Econometrics*, McGraw Hill
3. Cramer J.S: *Empirical Econometrics*, North Holland
4. Koutsoyiannis: *Theory of Econometrics*, Macmillan Press
5. Theil H: *Introduction to the theory and practice of Econometrics*, John Wiley.
6. Desai M: *Applied Econometrics*, Mc Graw Hill.

**SEMESTER-IV**  
**Paper: STA1004C**  
**Special Papers (Any one)**

**Paper: STA1004C (A)**  
**ACTUARIAL STUDIES –II**  
**Credits: 4 (3+1+0)**

Actuarial Statistics: Life insurance, life annuities, net premiums, net premium reserves, mortality profit/loss and Theiele's equation. Joint insurance.

Reinsurance: deductibles, retention limits, proportional and excess of loss/stop-loss reinsurance.

Credibility Theory: credibility premium, credibility factor, Bayesian and empirical approaches, applications to credibility premiums for standard models.

Special topics: Experience rating, runoff triangles.

**References:**

1. Bowers et al. 1997: *Actuarial Mathematics*. Second Edition. Society of Actuaries.
2. Rob Kaas Marc Goovaerts, Jan Dhaene and Michel Denuit (2008) : *Modern Actuarial Risk Theory using R*, Springer.
3. Trowbridge, C. L. (1989): *Fundamental Concepts of Actuarial Science*, Actuarial Education and Research Fund, USA.
4. Slud, E.V. (2001): *Actuarial Mathematics and Life-Table Statistics*, University of Maryland, USA.

**Paper: STA1004C (B)**  
**BIO-STATISTICS-II**  
**Credits: 4 (3+1+0)**

**Part 1: Statistical Genetics & Survival Analysis**

**50**

**Statistical Genetics**

Basic biological concepts in genetics (relevant to this course)

Mendel's law, Hardy Weinberg equilibrium. Mating tables, estimation of allele frequency (dominant/ co-dominant cases). Approach to equilibrium for X-linked gene, natural selection, mutation, genetic drift, equilibrium when both natural selection and mutation are operative.

**Survival Analysis**

Basic concepts of survival time distributions, brief idea of some survival distributions, detailed discussion on censoring and truncation.

Non-parametric estimation of basic qualities for right censored data – Product limit estimator, Nalson-Aalen estimator.

Two sample problem – Gahen's generalized Wilcoxon test, The Cox-Mantel test, The log Rank test.

**Part 2: Clinical Trials**

**50**

Introduction: The rational of Clinical trials. The Historical Development of Clinical trials.

Organization and Planning. The Justification of Randomized Controlled Trails.

Methods of Randomization: Stratified randomization, Unequal randomization Blinding and Placebos.

Crossover Trails. The size of a clinical trial. Monitoring Trial progress.

Forms and Data management. Protocol Deviations.

Basic Principles of Statistical Analysis: Describing the data, Significance tests, estimation and confidence limits. Publication and interpretation of findings.

**References:**

1. S. J. Pocock (1986): *Clinical Trials: A Practical Approach*, John Wiley & Sons.
2. L M Friedman, C D Furberg, and D L DeMets (1999) : *Fundamentals of Clinical Trials*, Springer.

**Paper: STA1004C (C)**  
**OPERATIONS RESEARCH - II**  
**Credits: 4 (3+1+0)**

**Reliability Theory:** **50**

Concept and Measures, Notion of Ageing, Hazard rate, IFR and DFR distributions and related Theorem, Structure Function, Coherent Systems, Component and Systems, Reliability of Coherent Systems. Life distributions (Exponential, Gamma, Weibull etc.), Stress- Strength Model. System Reliability under Markovian setup – Series and Parallel.

**Game Theory:** **30**

Introduction to Game theory: Two person Zero sum game; The Minimax-Maximin Principle; saddle points; Game without saddle point; Pure and Mixed strategies; Solution procedure of 2 x 2 game; Graphical solution procedure; Equivalence of Rectangular game and linear programming.

**Non linear programming :** **20**

Unconstrained problems, Kuhn-Tucker conditions, Quadratic programming- Beale's and Wolfe's methods for solving quadratic programming problems.

**References:**

1. Barlow, R.E,Proschan,F (1980): *Statistical Theory of Reliability and LifeTesting*, Holt, Rinehart and Winston.
2. Lawless, J. F (1982) : *Statistical Models and Methods of Life Time Data*, John Wiley.
3. Zacks S. : *Reliability Theory*, Springer
4. Gass SL: *Linear Programming* , John Wiley.
5. Swarup, K and Gupta, P.K: *Operations Research*, Mac Mohan
6. Ravindran, A, Phillips, D.T and Slosberg, J.J.: *Operations Research*
7. Hiller and Libermann : *Operations Research*

**Paper: STA1004C (D)**  
**SURVIVAL ANALYSIS - II**  
**Credits: 4 (3+1+0)**

Unit 1:

Test of exponentiality against non-parametric classes- total time on test. Deshpande test.

Unit 2:

Two sample problem- Gehan test, Log rank test. Mantel- Hanzel test, Tarone-Ware.

Unit 3:

Semi parametric regression for failure rate- Cox's proportional hazard model with one and several



covariates. Rank test for the regression coefficient.

Unit 4:

Competing risks model, parametric non-parametric inference for this model.

Multiple decrement life table.

**References:**

1. Cox D. R. And Oakes (1984): *Survival Analysis*, Chapman and Hall. New York
2. Gross A. J. and Clark V. A. (1975): *Survival distribution: Reliability applieasis in Biomedical sciences*. John Wiley and Sons.
3. Elandt- Johnson, R. E. Johnson N.L.: *Survival models and Data Analysis*, John Wiley and sons.
4. Miller- R.G.(1981): *Survival Analysis*.
5. Kalbfleisen, John Wiley, J. D. and Prentice R.T (1980): *The statistical Analysis of failure Data*, John Wiley.

**Paper: STA1004C (E)**

**DEMOGRAPHY - II**

**Credits: 4 (3+1+0)**

Unit 1

Theory of stable population. One sex model. Concept of stationary, stable and quasi stable population

Unit 2:

Multistate Demography. Multistate life tables, Multiregional life tables, Multiregional stable population.

Unit 3:

Methods of estimating basic demographic measures from incomplete data, Brass two parameter logit system, Nuptiality; Different measures nuptiality tables- net and gross Hanjal's method.

Unit 4:

Migration: Internal and international migration. Models for migration. Stochastic models for migration and for social and occupational mobility based on Markov Chain.

Unit 5:

Discrete Branching Process: Basic theory, Probability of extinction, Branching process as a population model. Survival Distribution.

**References:**

1. Shryock, H. S, Seigal, J. S and Associates (1997): *Methods and Materials of Demography*, Academic Press Inc., London
2. Chiang, C. L (1968): *Introduction to Stochastic Process in Biostatistics*, John Wiley
3. Keyfitz, N (1977): *Applied Mathematical Statistics*, Springer Verlag.
4. Cox P. R (1970): *Demography*, Cambridge University Press
5. Spiegelman, M (1969): *Introduction to Demographic Analysis*, Harvard University Press.
6. Namboodiri and Suchindran (1986): *Life Table and its applications*, Academic Press.

**Paper: STA1004C (F)**  
**ASTRO STATISTICS - II**  
**Credits: 4 (3+1+0)**

Coordinate systems, precession, time, heliocentric corrections; methods of observation, resolution, methods of data reduction, Fourier transforms, calibrations; Numerical techniques, errors and error propagation, numerical integration and interpolation, random numbers, astrostatistics, probability distributions, hypothesis testing, sampling methods, multivariate analysis, regression, time-series analysis, data reduction, error analysis, numerical solutions of algebraic, ordinary differential and partial differential equations.

**References:**

1. G.Beutler, L.Mervert & A.Verdun : *Methods of Celestial Mechanics* ; Vol I & II :
2. S.M.Miyama, K.Tomisaka & T Hanawa: *Numerical Astrophysics*
3. P.Hellings : *Astrophysics with a PC : An Introduction to Computational Astrophysics* :
4. P.N.Tan, M.Steinbach & V.Kumar : *Introduction to Data Mining*
5. J.G.Babu & E.D.Fiegelson : *Astrostatistics*

**SEMESTER-IV**  
**Paper: STA1005E**

**USE OF PACKAGES FOR STATISTICAL DATA ANALYSIS**  
**Credits: 3 (1+1+1)**

Unit 1: **40**  
Functional Language R - Introduction and overview of package, basic operations, data handling, input-output operations.  
Basic Programming : data types, arrays, loops etc; functions and graphics.  
Statistical computations – data summary and graphical display of data, basic statistics. Simulation from probability distributions, comparisons of distributions, Q-Q and P-P plots.

Unit 2: **60**  
Data analysis with Excel.  
Statistical data analysis using SPSS : Introduction to SPSS, creating, defining and modifying data in SPSS, Descriptive Statistics, Correlation and Regression, Cross tabulations, Curve estimations, ANOVA for one way classified data, ANOVA for two way classified data.

**Practicals:** Data analysis using R and SPSS.

**References:**

- 1) Manual of SPSS.
- 2) Everitt, B. S. and Hothorn, T. : *A Handbook of Statistical Analysis using R*