



Statistics Syllabus CBCS Pattern (New Course)
Master in Science (M.Sc)
Department of Statistics, Assam University, Silchar

Course No.	Title
Semester I	
101	Real Analysis
102	Linear Algebra
103	Probability Theory
104	Distribution Theory
105	Statistical Computing (Practical Paper)
Semester II	
201	Linear Models and Regression Analysis
202	Survey Sampling
203	Fundamentals of Data Collection and Analysis (CBCS paper open to PG students of other departments)
204	Statistical Inference I (CBCS paper open to all PG students)
205	Computer Programming (Practical Paper)
Semester III	
301	Design and Analysis of Experiments
302	Statistical Inference – II
303	Stochastic Process
304	Applied Statistics – I
305	Statistical Software (Practical Paper)
Semester IV	
401	Multivariate Analysis
402	Applied Statistics – II
403	(i) Industrial Statistics and Optimization Techniques I or (ii) Actuarial Statistics I
404	(i) Industrial Statistics and Optimization Techniques II or (ii) Actuarial Statistics II
405	Project Work

Note:

1. Each of the papers shall be of equal credit.
2. Students shall be exposed both to statistical theory and statistical computing.
3. Any one of the two modules in paper 403 and 404 will be offered to the students as specialization, i.e. either 403(i) and 404(i) or 403(ii) and 404(ii).
4. The Project Work shall be an application of statistical theory to practice. Students are supposed to identify a practical problem, collect necessary data, analyse them using statistical methods and report the findings.

**First Semester
Paper 101
REAL ANALYSIS**

Unit I

Elements of set theory, Algebra of Sets, Open Sets, Closed Sets, bounded and unbounded sets, supremum, infimum. Introduction to real numbers, Completeness in the set of Real numbers.

n-dimensional Euclidian space; open and closed intervals (rectangles), compact sets, Bolzano- Weirstrass theorem, Heine – Borel theorem. (9 lectures)

Unit II

Sequences, Cauchy's general principle of convergence, Algebra of sequence, Infinite series, different tests of convergence of series. (9 lectures)

Unit III

Real valued functions, continuous functions, uniform continuity, Uniform convergence; Power series and Fourier series and Differentiation of functions (9 lectures)

Unit IV

Mean value theorems and applications, Taylor's theorem, maxima - minima of single variable functions; maxima - minima of functions of several variables, constrained maxima - minima of functions. (9 lectures)

Unit V

Double and multiple integrals, evaluation of multiple integrals by repeated integration. Change of variables in multiple integration. Uniform convergence in improper integrals, differentiation under the sign of integral. (9 lectures)

REFERENCES

- Apostol, T. M. (1985). Mathematical Analysis, Narosa, Indian Ed.
- Royden H. L., Fitzpatrick P. M (2011). Real Analysis (4th edition), PHI Learning.
- Malik, S. C. and Arora, S. (2002). Mathematical Analysis, New Age International Ltd.
- Protter, M. H. Basic Elements of Real Analysis, Springer

First Semester
Paper 102
LINEAR ALGEBRA

Unit I

Fields, vector spaces, subspaces, linear dependence, basis and dimension of a vector space, completion theorem, linear equations. (9 lectures)

Unit II

Vector spaces with an inner product, Gram-Schmidt orthogonalization process, orthogonal and orthonormal basis and orthogonal projection of a vector, Orthogonal transformation, Projective transformation and their Statistical Applications (9 lectures)

Unit III

Matrices, Types of matrices, algebra of matrices, row and column vectors of a matrix, determinants, rank and inverse of a matrix, partitioned matrices, characteristic roots and vectors, Cayley – Hamilton theorem, minimal polynomial. (9 lectures)

Unit IV

Generalized inverse of a matrix, Moore and Penrose generalized inverse, Applications of generalized inverse.
Quadratic form of a matrix, Gram Matrix, Lagrange's transformation of quadratic form, Cochran's Theorem. (9 lectures)

Unit V

System of linear equations, Gaussian elimination and back substitution, Row Echelon form, existence of solutions, uniqueness of solutions. (9 lectures)

REFERENCES

- Kunze Ray, Hoffman Kenneth (2008) Linear Algebra, 2nd Edition, PHI Learning Pvt. Ltd.
- Seymour Lipschutz, Marc Lipson (2005) Linear Algebra 3rd Edition, Tata McGraw Hill.
- Biswas, S. (2012). Textbook of Matrix Algebra, PHI, New Delhi
- Bhimasanam P., A. Ramachandra Rao (2010) Linear Algebra (Texts and Readings in Mathematics) 2nd Revised edition, Hindustan Book Agency
- Dasgupta A. (2014) Abstract and Linear Algebra, Ashoke Prakashan, Kolkata

First Semester
Paper 103
Probability Theory

Unit I

Fields, sigma-fields, minimal sigma-field, Borel sigma-field in R_k , sequence of sets, limsup and liminf of a sequence of sets. Measure, Probability measure, properties of a measure, Lebesgue and Lebesgue-Steljes measures on R_k , (9 lectures)

Unit II

Measurable function, Simple functions, Integrability of simple functions, Probability space, Basic terminologies and theorems on probability, Independence of events, conditional probability, Bayes' Theorem and its applications (9 lectures)

Unit III

Random Variable, Functions of random variables (discrete and continuous), Distribution functions, Bi-dimensional and Multi-dimensional random variables, marginal and conditional distributions, expected values, moments, some related inequalities. (9 lectures)

Unit IV

Generating functions, characteristic function, uniqueness theorem, inversion theorem, joint characteristic function, Convergence of sequence of random variables, Urn Models (9 lectures)

Unit V

Weak law of large numbers, Chebychev's law of large numbers. Khinchin's theorem and its applications. Contilli's lemma, Borel zero-one law .
Kolmogorov's strong law of large numbers (both iid and non-iid cases).
Demoivre-Laplace central limit theorem. Lindeberg-Levy's central limit theorem.
Statement and discussion of Lindeberg- Feller's theorem. (9 lectures)

REFERENCES

- Hogg R.V., Craig, A. And McKean J. W. (2005) Introduction to Mathematical Statistics, 6th Edition, Pearson
- Feller, W. (1985). Introduction to Probability Theory and its Applications, Wiley Eastern, New Delhi
- Singh, B.M. (2002). Measure, Probability & Stochastic Processes, South Asian publishers, New Delhi.
- A. K. Md. Ehsanes Saleh and Vijay K. Rohatgi (2010) An Introduction to Probability and Statistics, Wiley India Pvt. Ltd.
- Das K. K. and Bhattacharjee D. (2008). An Introduction to Probability Theory, Asian Books, New Delhi.

First Semester
Paper 104
Distribution Theory

Unit I

Univariate discrete distributions; properties and application of binomial, Poisson, hypergeometric, geometric and negative binomial distribution. (9 lectures)

Unit II

Univariate continuous distributions; statement, derivation of properties and applications of normal, exponential, beta, gamma, Cauchy, Weibull and lognormal distributions (9 lectures)

Unit III

Bivariate distributions, Bivariate Normal Distribution, Properties and applications, Derivation and properties of chi-square, t and F distributions and their inter relationship (9 lectures)

Unit IV

Derivation and properties of non-central chi-square, t and F distributions, Compound distribution, truncation of distributions. (9 lectures)

Unit V

Order Statistics, Distribution of r^{th} order statistics, Joint density of two order statistics, some special joint distributions resulting from order statistics. Mixture distribution (definition, finite mixtures and zero modified distributions, mixtures of binomial distribution), extreme value distributions. (9 lectures)

REFERENCES

- Hogg R.V., Craig, A. And McKean J. W. (2005) Introduction to Mathematical Statistics, 6th Edition, Pearson
- Freund, J. E. (1998). Mathematical Statistics, PHI, New Delhi
- Biswas, S. (2002). Topics in Statistical Methodology, New Age International Publishers, New Delhi.
- Johnson, S and Kotz (1995). Distributions in Statistics, Vol – I, II and III, Houghton and Mifflin.
- Wilks S.S. (2007). Mathematical Statistics, Buck Press
- Das K. K. and Bhattacharjee D. (2008). A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi

First Semester
Paper 105
Statistical Computing (Practical Paper)

List of Practicals

The objective of this paper is to enrich the computing power of students using spreadsheets and packages like R and Matlab. The paper will help the students to understand how to go around with the computing part of some of the theoretical aspects electronically.

To be performed using Microsoft Excel/R/Matlab

1. Computation of Determinants of matrix
2. Inverses of a matrix by partitioning
3. Rank of a matrix
4. Solutions of matrix equations
5. Characteristic roots and vectors of a matrix
6. Fitting of binomial distribution and testing the goodness of fit
7. Fitting of Poisson distribution and testing the goodness of fit
8. Fitting of negative binomial distribution and testing the goodness of fit
9. Fitting of multinomial distribution
10. Fitting of normal distribution and testing the goodness of fit
11. Fitting of lognormal distribution and testing the goodness of fit
12. Common tests of significance like t-tests, F-test and Chi-Square tests
13. Numerical Integration
14. Root extraction using different methods
15. Random number generation from different distributions
16. Simple exercise on simulation
17. Producing simple statistical graphs in R

REFERENCES

- Gardener M. (2010) Beginning R : The Statistical Programming Language, Wiley India Pvt. Ltd., New Delhi
- Bhattacharjee, D. (2010). Practical Statistics using Microsoft Excel, Asian Books, New Delhi
- Levine, D. M., Stephan, D., Krehbiel, T.C. and Berenson, M.L. (2006). Statistics for Managers Using Microsoft Excel, Prentice Hall of India Pvt. Ltd., New Delhi.
- Bruce L.L. and Hanselman D. C. (1996). Mastering Matlab 7,
- Gilat A. (2004) Matlab: An Introduction with Applications, 4th Edition, Wiley India Pvt. Ltd., New Delhi
- Albright, S.C., Winston, W. L. and Zappe C. J. (2009) Decision Making Using Microsoft Excel, Cengage Learning, New Delhi.

Second Semester
Paper 201
Linear Models and Regression Analysis

Unit I

Simple linear regression, estimation and tests of hypothesis associated with the parameters of regression, confidence interval and bands for slope and intercept, evaluating the goodness of fit, residual analysis, effect of outliers, transformation of variables. Interclass correlation, correlation ratio. (9 lectures)

Unit II

Straight line regression through origin, weighted least squares, inverse regression, comparing straight lines, two phase linear regression, multiple regression, properties of least square estimators, estimation and testing related to regression parameters, inclusion of qualitative variables as regressors, multiple and partial correlations (9 lectures)

Unit III

Problem of correlated errors, detection and removal of auto-correlation, Variance-covariance of least square estimators, estimation of error variance, case with auto-correlation, detection and correction of multicollinearity, ridge regression. (9 lectures)

Unit IV

Non-linear regression, polynomial in one variable, orthogonal polynomials, polynomial regression in several variables, Gompertz and Logistic non-linear growth models (9 lectures)

Unit V

Logistic regression, logit transformation, maximum likelihood (ML) estimation, tests of hypothesis: Wald test, likelihood ratio (LR) test, score test, test for overall regression, multiple logistic regression; forward and backward method, Interpretation of parameters. (9 lectures)

REFERENCES

- Seber, G.A.F (1977) Linear Regression Analysis, John Wiley and Sons, New York
- Joshi, D.D. (2009) Linear Estimation and Designs of Experiment, New Age International Publishers, New Delhi.
- Chatterjee, S. and Price, B. (1995) Regression Analysis by Example, John Wiley and Sons, New York.
- Rao, C. R. (1973) Linear Statistical inference and its Applications. Wiley Eastern.
- Draper, N.R. and Smith, H. (1998) Applied Regression Analysis, John Wiley, New York
- Seber, G.A.F and Wild, C.J. (1989). Nonlinear Regression, John Wiley, New York

Second Semester
Paper 202
Survey Sampling

Unit I

Review of basic finite population sampling techniques. Simple random sampling with and without replacement. Stratified sampling. Allocation problem and construction of strata.

(9 lectures)

Unit II

Unequal probability sampling: pps with replacement/without replacement methods [including Lahiri's scheme] and related estimators of a finite population mean, Hansen-Hurwitz and Desraj estimators for a general sample size and Murthy's estimator for a sample of size 2.

(9 lectures)

Unit III

Ratio method of estimation (Hartley Ross and Jackknife estimators), combined ratio estimator and regression estimators based on srsWOR method of sampling. Combined ratio estimator

(9 lectures)

Unit IV

Cluster sampling with clusters of equal and unequal sizes. Two-stage and Multi-stage sampling, systematic sampling.

(9 lectures)

Unit V

Non sampling errors, errors in survey, modeling observational errors. Randomized response technique (Wamer's model only). Basics of distance sampling, Non-probability sampling techniques, snowball network sampling and importance sampling.

(9 lectures)

REFERENCES

- Cochran, W.G. (1997). Sampling Techniques, Wiley Eastern, New Delhi.
- Mukhopadhyay, P.(1998). Theory and Methods of Survey Sampling, Prentice Hall of India, New Delhi.
- Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. (1984). Sampling Theory of Surveys with Applications, Iowa State University Press and IARS.
- Murthy, M.N. (1977). Sampling Theory and Methods, Statistical Publishing Society, Kolkata.
- Chaudhury, A. and Mukherjee, R. (1988). Randomized Response: Theory and Techniques, Marcel Decker, New York.

Second Semester
Paper 203
Fundamentals of Data Collection and Analysis
(CBCS Paper open to PG students of other departments)

Unit I

Measures of Central Tendency (including windsorized mean and trimmed mean), Measures of Dispersion (including relative measures), Outliers, normalization and standardization of data, unweighted composite index. (9 lectures)

Unit II

Primary data, method of data collection, secondary data and its sources, random and non-random sampling techniques and their types, determination of sample size, scaling techniques (9 lectures)

Unit III

Correlation (Karl Pearson's, Spearman's, Point-biserial, Phi and Kendell's), scatter plot, lines of regression, residual analysis, r^2 for model fit, outlier detection, association of attributes, Coefficient of association, Coefficient of colligation, Goodman and Kruskal's Gamma, Kendall's tau-a, b, c, Somers' d (9 lectures)

Unit IV

Measures of disease frequency, prevalence and incidence, crude, specific and standardized rates, risk ratio, odds ratio, confounding, Mantel-Haenszel odds ratio, infant and maternal mortality rates (9 lectures)

Unit V

Levels of measurement, measurement of agreement, data management, data coding, data cleaning, data processing, rectangular data file, missing data analysis. (9 lectures)

REFERENCES

- Madsen B. (2008) Statistics for Non-statistician, Springer
- Urdan, TC. (2005). Statistics in Plain English, Lawrence Erlbaum Associates Publishers
- Gun AM., Gupta MK. And Dasgupta B. (2001) Fundamentals of Statistics, Vol. 1, World Press.
- Boslaugh S and Watters PA (2008) Statistics in a Nutshell, O'Really
- Naresh K. Malhotra and Satyabhusan Dash (2010) Marketing Research: An Applied Orientation, Fifth Edition, Pearson Education.
- D. A. deVaus (2003) Surveys in Social Research, Fifth edition, Allen and Unwin, Australia.
- Rumsey D. (2007) Intermediate Statistics for Dummies, Wiley Publishing, Inc.

Second Semester
Paper 204
Statistical Inference I
(CBCS Paper open to all PG Students)

Unit I

Point estimation, properties of estimators: unbiasedness, consistency, sufficiency.
Neyman factorization criterion, completeness. (9 lectures)

Unit II

Minimum variance, mean square error, BLUE, minimum variance unbiased estimators, C-R inequality, Rao-Blackwell Theorem, Lehmann-Scheffe theorem (9 lectures)

Unit III

Exponential class of densities and its properties, Types of estimation- Method of Maximum Likelihood, Method of moments (9 lectures)

Unit IV

Tests of hypothesis, concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test, Neyman-Pearson Lemma, MP test for simple null against simple alternative hypothesis. UMP tests for simple null hypothesis against one-sided alternatives and for one-sided null against one-sided alternatives in one parameter exponential family. (9 lectures)

Unit V

Interval estimation, confidence level, construction of shortest expected length confidence interval, Uniformly most accurate one-sided confidence Interval and its relation to UMP tests for one-sided null against one-sided alternative hypotheses. (9 lectures)

REFERENCES

- Hogg RV., Craig, A. & McKean JW. (2005) Introduction to Mathematical Statistics, Ed. 6, Pearson
- Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.
- Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.
- Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.
- Rao, C.R. (1973). Linear Statistical Inference and its Applications, 2nd Edn., Wiley Eastern Ltd., New Delhi.
- Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
- Biswas, S. (2002). Topics in Statistical Methodology, New Age International Pub., New Delhi.
- Wilks S.S. (2007). Mathematical Statistics, Buck Press
- Dudewicz, E. J. and Mishra, S.N.(1988) Modern Mathematical Statistics, John Wiley
- Das K. K. and Bhattacharjee D. (2008). A Treatise on Statistical Inference and Distributions, Asian Books, New Delhi

Second Semester
Paper 205
Computer Programming (Practical Paper)

Objective

The objective of this paper is to enrich the computing power of students and provide them an overview of the programming skills in C language. The paper will help the students to understand how to go around with the computing by writing their own program.

Programming in C

Introduction to object-oriented programming concepts.

Programming in C: Data types, Variables, Operations and Expressions, functions and parameters, input/output, control statements such as if-else, switch, for, while and do-while, pointers, arrays (one dimensional and multi dimensional), character strings and library functions.

List of Practicals

Using the knowledge of C students are expected to program the following:

1. Factorial of a positive Integer
2. Ordering of a given set of observations
3. Finding maximum and minimum of a given set of observations.
4. Mean, variance and quantiles for ungrouped and grouped data.
5. Correlation coefficients for ungrouped data, Intra-class correlation coefficient.
6. Fitting of exponential curve and straight line to the given data.
7. Fitting of Binomial and Poisson distributions.
8. Drawing of random samples from Binomial, Poisson, Normal and Gamma distributions.
9. Fitting of standard distributions and tests for goodness of fit.
10. Method of Estimation: Moments, MLE, MLE for location parameter of Cauchy distribution.
11. Tests of significance: Drawing of power curve of a test. Test based on Chi-square, t and F statistics and related confidence intervals.
12. Large sample tests.
13. Construction of difference table, Forward, Backward and Central difference interpolation formulae. Divided difference table. Newton's divided difference and Lagrange's interpolation formula.
14. Numerical Integration: Trapezoidal Rule, Simpson's 1/3rd rule and Weddle' formula for numerical integration.
15. Operations of Matrix algebra and computation of the inverse of a matrix.

REFERENCES

- Schildt H. (1990) Teach Yourself C, Osborne/McGraw Hill.
- Kanitkar Y. (2013) Let us C, Thirteenth Edition, BPB Publications
- Srivastava S K and Srivastava D. (2009) C in Depth, BPB Publications
- Kernighan B K and Ritchie, D.M. The C Programming Language (ANSI C Version), Prentice Hall of India.
- Balagurusamy E. (2012) Programming in ANSI C, Tata McGraw Hill.
- Gottfried B., (1996) Schaum's Outline of Programming with C, McGraw Hill.

Third Semester
Paper 301
Design and Analysis of Experiments

Unit I

Review of linear estimation, Analysis of Variance: one way, two way (with $m=1$, $m>1$) observations per cell, Fixed Effect, Random Effect and Mixed Effect, Two way classified data with unequal number of observations in cells, Analysis of Co-variance (9 lectures)

Unit II

Orthogonal Contrasts, Application of ANOVA in the study of relationship: between two variables, linearity of regression, polynomial regression, homogeneity of group regression coefficients, multiple linear regression model, Non parametric ANOVA (9 lectures)

Unit III

Designs of Experiment: Basic Principles, basic designs and their analysis, relative efficiency, missing plot analysis, Graeco-Latin Square Design. (9 lectures)

Unit IV

Factorial experiments, factorial effects, study of 2 and 3 factorial experiments in randomized blocks. Complete and partial confounding. Symmetrical factorial experiments (s^m , where s is a prime or a prime power), confounding in s^m factorial experiments, s^{k-p} fractional factorial where s is a prime or a prime power (9 lectures)

Unit V

BIBD- Recovery of Interblock information, Concepts and Connectedness, Orthogonality and Balance. Intrablock analysis of General Incomplete Block design, Split-plot and Strip plot Design. (9 lectures)

REFERENCES

- Cochran, W.G. and Cox, G.M. (1959). Exponential Designs, Asia Publishing House, Singapore.
- Das, M.N. and Giri, N.C. (1986). Design and Analysis of Experiments, Wiley Eastern Limited.
- Dean, A. and Voss, D. (1999). Design and Analysis of Experiments, Springer. First Indian Reprint 2006.
- Joshi, D.D. (1987). Linear Estimation and Design of Experiments, Wiley Eastern, New Delhi.
- Montgomery, D.C. (2005). Design and Analysis of Experiments, Sixth Edition, John Wiley and Sons.
- Raghavarao, D. (1970). Construction and Combinational Problems in Design of Experiments, John Wiley and Sons.

Third Semester
Paper 302
Statistical Inference II

Unit I

The Likelihood Ratio Test, One-tailed and two-tailed likelihood ratio tests for mean and variance of normal populations, Asymptotic property of LRT and applications, Monotone Likelihood Ratio Test and applications, Similar tests (9 lectures)

Unit II

Overview of Bayesian inference, Concept of Prior and Posterior distributions, Types of prior and relevant computation, Bayesian estimation and Bayes rules, Loss functions. (9 lectures)

Unit III

Bayesian Testing of hypothesis, Lindley's method, Tests of point null hypothesis, Jeffreys Test for normal mean, Credible Intervals and their applications, Bayesian prediction. (9 lectures)

Unit IV

Sequential tests, Wald's Sequential Probability Ratio test, Properties of SPRT, Efficiency, Fundamental identity, Operating Characteristics and average sample number, Application of SPRT in decision making. (9 lectures)

Unit V

Non-parametric methods, Tests of goodness of fit: Chi-square, K-S Test, Sign tests, Run tests, Mann-Whitney's U Test, test of significance of rank order correlations, non-parametric estimation and confidence interval. (9 lectures)

REFERENCES

- Ferguson, T.S.(1996). Mathematical Statistics- A Decision theory Approach, Academic Press, London.
- Gibbons, J.D. and Chakraborti, S. (1992). Non-parametric Statistical Inference, Marcel Dekker, New York.
- Randles, R.H. and Wolfe, D.S. (1979). Introduction to the Theory of Non-Parametric Statistics, John Wiley and Sons.
- Rao, C.R. (1973). Linear Statistical Inference and Its Applications, Second Ed., Wiley Eastern Ltd.
- Rohatgi, V. and Saleh, A.K.Md. E (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.
- Ghosh, J.K., Delampady, M. And Samanta T. (2006) An Introduction to Bayesian Analysis Theories and Methods, Springer International Edition.
- Lee P. M. (1989) Bayesian Statistics: An Introduction, Edward Arnold.

Third Semester
Paper 303
Stochastic Process

Unit I

Classification of Markov Chains, Higher transition probabilities in Markov Classification of States and Chains. Stability of a Markov System. Limiting behaviour: Irreducible ergodic chain. (9 lectures)

Unit II

Markov Processes with discrete state space: Poisson process and its properties, Simple Birth and Death Process, Martingales, Martingale convergence theorems. (9 lectures)

Unit III

One-dimensional, two-dimensional and three-dimensional random walks, Correlated random walk. Gambler's ruin problem. (9 lectures)

Unit IV

Introduction to Brownian Motion and Wiener process, Branching Process, Chance of Extinction. (9 lectures)

Unit V

Renewal Processes, Renewal Processes in Continuous Time, Stopping time: Wald's Equation, Elementary Renewal Theorem, Delayed and Equilibrium Renewal Processes (9 lectures)

REFERENCES

- Bailey, Norman, T.J. (1964). The Elements of Stochastic Processes, John Wiley and Sons.
- Bartlett, M.S. (1966). An Introduction to Stochastic Processes, Cambridge University Press.
- Bhat, B.R. (2000). Stochastic Models- Analysis and Applications, New Age International Publishers.
- Feller, William (1968). An Introduction to Probability Theory and its Applications, Vol. 1 (Third Ed.) John Wiley.
- Karlin, S. and Taylor, H.M. (1975). A First Course in Stochastic Processes, (Second Ed.), Academic Press.
- Medhi, J. (1994). Stochastic Processes, Second Edition, Wiley Eastern Ltd.
- Ross, S.M. (1983). Stochastic Processes. John Wiley and Sons.

Third Semester
Paper 304
Applied Statistics I

Unit I

Statistics for National Development- Economic development: Growth in per capita income and distributive justice. Indices of development, Human Development Index. Estimation of national income - product approach, income approach and expenditure approach.

(9 lectures)

Unit II

Measures of mortality and fertility, Life table: complete and abridged, King's method, Greville's method, Reed and Merrell method, Chiang's method, uses of life table, graduation of mortality rates.

(9 lectures)

Unit III

Population growth in developing and developed countries. Population projection using Component method, Leslie matrix. Labour force projection. Measuring inequality in incomes, Gini coefficient, Theil's measure. Poverty measurement - different issues, measures of incidence and intensity, combined measures e.g., indices due to Kakwani, Sen etc.

(9 lectures)

Unit IV

Official Statistics- Indian and International statistical systems: Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys. Role of National Sample Survey Organization, General and special data dissemination systems.

(9 lectures)

Unit V

System of collection of agricultural statistics, Crop forecasting and estimation, productivity, impact of irrigation projects. Statistics related to industries, foreign trade, and balance of payment, cost of living, inflation, educational and other social statistics.

(9 lectures)

REFERENCES

- Basic Statistics Relating to the Indian Economy (CSO) 1990.
- Guide to Official Statistics (CSO) 1999.
- Keyfitz, N. (1977). Applied Mathematical Demography, Springer Verlag.
- Benjamin, B. (1969). Demographic Analysis, George, Allen and Unwin
- Panse, V.G., Estimation of Crop Yields (FAO).
- Principles and accommodation of National Population Censuses, UNESCO
- Statistical System in India (CSO) 1995.
- Sen, A. (1997). Poverty and Inequality.
- UNESCO. Principles for Vital Statistics Systems. Series M -12.
- Gun AM., Gupta MK. And Dasgupta B. (2001) Fundamentals of Statistics, Vol. 2, World Press.

Third Semester
Paper 305
Statistical Software (Practical Paper)

Objective

The objective of this paper is to introduce the students to at least one of the popular Statistical Software Packages that are commonly used. The paper shall provide them with an overview of the application and the different computational facilities provided in the package. Along with common tools of data analysis like regression, Descriptive Statistics, Tests of Significance both parametric and non-parametric, Graphical tools and data manipulation tools shall also introduced.

REFERENCES

- Field A. (2013) Discovering Statistics Using SPSS, Sage Publications.
- Gilat. (2010) MATLAB: An Introduction with Applications, BPB Publications
- Singh YK and Chaudhuri BB (2008) MATLAB Programming, PHI, New Delhi
- Carver RH. and Nash JG. (2012) Doing Data Analysis in SPSS: Version 18.0, CENGAGE Learning.
- Hamilton LC. Statistics with STATA: Version 12, CENGAGE Learning.
- Khan RM. (2013) Problem Solving and Data Analysis using Minitab, Wiley.

Fourth Semester
Paper 401
Multivariate Analysis

Unit I

Multinomial distribution, Bivariate normal distribution, Multivariate normal distribution its properties and characterization, Random sampling from a multivariate normal distribution. Maximum likelihood estimators of parameters. Distribution of sample mean vector.

(9 lectures)

Unit II

Wishart matrix- its distribution and properties, Distribution of sample generalized variance, Null and non-null distribution of sample correlation coefficient. Null distribution of partial and multiple correlation coefficients. Distribution of sample regression coefficients. Application in testing and interval estimation.

(9 lectures)

Unit III

Null distribution of Hotelling's T^2 statistic, application in tests on mean vector for one or more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population.

(9 lectures)

Unit IV

Classification and discrimination procedures for discrimination between two multivariate normal populations – sample discriminant function, tests associated with discriminant functions, Principal component, Dimension reduction, Canonical variables and canonical correlation, Factor analysis.

(9 lectures)

Unit V

Multivariate linear regression model; estimation of parameters, tests of linear hypotheses. Likelihood ratio test criterion, Multivariate analysis of variance (MANOVA) of one way classified data.

(9 lectures)

REFERENCES

- Anderson, T.W. (2003). An Introduction to Multivariate Statistical Analysis, Third Edition, John Wiley & Sons.
- Arnold, Steven F. (1981). The Theory of Linear Models and Multivariate Analysis, John Wiley & Sons.
- Giri, N.C. (1977). Multivariate Statistical Inference, Academic Press.
- Johnson, R.A. and Wichern, D.W. (2007). Applied Multivariate Statistical Analysis, Sixth Edition, Pearson & Prentice- Hall.
- Kshirsagar, A.M. (1972). Multivariate Analysis, Marcel Dekker.
- Lawley, D.N. and Maxwell, A.E. (1971). Factor Analysis as a Statistical Method, Second Edition, London Butterworths.
- Muirhead, R.J. (1982). Aspects of Multivariate Statistical Theory, John Wiley & Sons.

Fourth Semester
Paper 402
Applied Statistics II

Unit I

Time-Series as discrete parameter stochastic process. Auto covariance and autocorrelation functions and their properties. Exploratory time series analysis, tests for trend and seasonality. Exponential and moving average smoothing, Holt and winters smoothing.

(9 lectures)

Unit II

Detailed study of the stationary processes: (i) moving average (MA) (ii) auto regressive (AR) (iii) ARMA and (iv) AR integrated MA (ARIMA) models. Box-Jenkin's models.

(9 lectures)

Unit III

Modelling and forecasting trend, selecting forecasting models, modelling seasonality, forecasting seasonal series, characterizing and modelling cycles, white noise, conditional forecasting models through regression

(9 lectures)

Unit IV

Estimation of survival function - Acturial Estimator, Kaplan -Meier Estimator, Estimation under the assumption of IFR/DFR. Tests of exponentiality against non-parametric classes, Total time on test.

(9 lectures)

Unit V

Measures of competing risks, Crude, Net and Partially crude probabilities (inter-relation and estimation), Dependent and independent risk, Analysis of censored data, Type I, Type II and Random Censoring.

(9 lectures)

REFERENCES

- Box, G. E. P. and Jenkins, G. M. (1976). Time Series Analysis - Forecasting and Control, Holden-day, San Francisco.
- Anderson, T. W. (1971). The Statistical Analysis of Time Series, Wiley, N. Y.
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Fourth Semester
Paper 403 (i)
Industrial Statistics and Optimization Techniques I

Unit I

Operations Research: Linear programming problems (LPP): Canonical and standard forms, and dual of an LPP, Graphical method to solve two variable LPP, solving LPP manually using Simplex procedure in presence of slack or/and surplus or/and artificial variables (9 lectures)

Unit II

Network analysis, Network Diagram, Time estimates, Critical Path Method, Product Evaluation and Review Technique, Time-cost optimization, Resource Allocation (9 lectures)

Unit III

Inventory Problems: Types of Inventory, Economic Order Quantity (EOQ) Model with Constant Rate of Demand, Limitations of EOQ formula, EOQ Model with Finite Replenishment Rate, Production Inventory Model, EOQ Model with Shortage. EOQ Model with Quantity Discounts. (9 lectures)

Unit IV

Lead time analysis, Reorder level, Buffer stock, Inventory control systems, Probabilistic inventory model, Probabilistic order-Level System (POLS), POLS with Instantaneous demand (9 lectures)

Unit V

Transportation models, Linear programming of transformation model, Initial feasible solution and optimum solution, Hungarian method, assignment problem, special cases in assignment problems. (9 lectures)

REFERENCES

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- H.A. Taha: Operations Research, Macmillan Publishing Co. Inc. (Edition 6, 1999).
- Nita H. Shah, Ravi M. Gor and Hardik Soni: Operations Research, Prentice Hall of India Private Limited.
- Kanti Swarup, Gupta, P.K. and Singh, M.M.. (1985) Operations Research; Sultan Chand & Sons.
- Churchman C.W., Ackoff R.L. and Arnoff E.L. (1957) Introduction to Operations Research; John Wiley.

Fourth Semester
Paper 404 (i)
Industrial Statistics and Optimization Techniques II

Unit I

Reliability: Definitions and Relationships between Survival Function, Failure Distribution, Hazard Function, Mean Time To Failure (MTTF), Reliability of Systems, Parametric Distributions - Weibull, Gamma, Lognormal and Exponential as life time Distributions. Derivation of reliabilities for these distributions (9 lectures)

Unit II

Reliability: Concept of Aging, IFR, IFRA classes of Distributions and their Dual, Coherent System as Binary Function: Minimal Cut and Path Sets (vectors), Representation of Structure Function of Series, Parallel and k out of n: G Systems of Independent Components. Redundancy: Parallel Redundancy, Standby Redundancy. (9 lectures)

Unit III

Queuing Theory, single-channel queuing model, queuing cost behaviour, multiple channel queuing model, Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queue length and waiting time. (9 lectures)

Unit IV

Simulation, its applications, Monte Carlo method, generation of random numbers from probability distributions, simulation in spreadsheets, variance reduction techniques, regenerative method. (9 lectures)

Unit V

Statistical quality control, process control, control charts for variables and attributes, modified control charts, CUSUM charts, product control, sampling inspection plans (one, two, multiple and sequential), sampling inspection by variables. (9 lectures)

REFERENCES

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- Grant E.L (1964). Statistical Quality Control, McGraw Hill.
- Duncan A.J (1974). Quality Control and Industrial Statistics, Taraporewala and Sons.

**Fourth Semester
Paper 403 (ii)
Actuarial Statistics I**

Unit I

Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, force of mortality, common loss distributions, collective risk models for a single period and for an extended period, ruin theory, applications. (9 lectures)

Unit II

Survival models, Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables. (9 lectures)

Unit III

Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups. (9 lectures)

Unit IV

Central rates of multiple decrements, net single premiums. Stationary Population. Mortality estimation: exposure to risk, approximation for incomplete data. Parametric, tabular and graphical methods, tests of graduation (9 lectures)

Unit V

Population Projections, distribution of aggregate claims, compound Poisson distribution and its applications. (9 lectures)

REFERENCES

- Bowers et al. (1997). *Actuarial Mathematics*, Second Edition. Society of Actuaries.
- N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt, (1986). 'Actuarial Mathematics', Society of Actuaries, Ithaca, Illinois, U.S.A. Second Edition (1997).
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- Trowbridge, C. L. (1989). *Fundamental Concepts of Actuarial Science*, Actuarial Education and Research Fund, USA.

Fourth Semester
Paper 404 (ii)
Actuarial Statistics II

Unit I

Principles of compound interest. Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. (9 lectures)

Unit II

Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, differed insurance and varying benefit insurance, recursions, commutation functions. (9 lectures)

Unit III

Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities due. (9 lectures)

Unit IV

Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. (9 lectures)

Unit V

Net premium reserves: Continuous and discrete net premium reserve, allocations of loss to policy years, commutation functions. Claim amount distributions, stop-loss insurance. Credibility Theory: credibility premium, credibility factor, Bayesian and empirical approaches, applications to credibility premiums for standard models. (9 lectures)

REFERENCES

- Atkinson, M.E. and Dickson, D.C.M. (2000). An Introduction to Actuarial Studies, Elgar Publishing.
- Bedford, T. and Cooke, R. (2001). Probabilistic risk analysis, Cambridge.
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**Fourth Semester
Paper 405
Project Work**

Objective

The objective of this paper is to train the students to undertake projects individually. The projects shall enable the students to take up their own statistical study and to understand the application of statistical methods that they learned during the course. The project requires the students to synthesize the topics from the course into some theme of practical use. They are expected to design computer programs or use statistical software for computational purpose. Students shall conduct their own independent statistical research, from start to finish. For the project each student shall work under the supervision of a faculty member of the department.

In consultation of the supervisor, students shall decide on a researchable topic for their project. The topic shall be presented before all faculty members for approval with details objective and methodology. Once approved the student shall work on the project. There shall be two mid term evaluation of the project to appraise the continuous progress. Before the start of the end-semester examination students are required to submit the project report/dissertation in hard copy in duplicate. During the end semester examination students shall present the same, whereby they shall be evaluated by an external examiner.