

Department of Statistics

Tripura University

(A Central University)

Suryamaninagar - 799022, Tripura, India



Dr. Prasenjit Sinha
Assistant Professor & Head (i/c)

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The BPGS meeting held on 13th July, 2015 at 10.30 AM in the Department of Statistics. The following members are present:

1. Professor Sangram Sinha, The Dean, Faculty of Science, TU.
2. Professor Dilip C. Nath, Gauhati University, Assam.
3. Professor Sudhansu S. Maiti, Visva-Bharati, Santiniketan.
4. Dr. Prasenjit Sinha, Asstt. Professor, Deptt. of Statistics, TU.
5. Sri Samrat Hore, Asstt. Professor, Deptt. of Statistics, TU.

The members discussed the agenda and following resolutions are taken.

1. The Chairman, BPGS in Statistics placed the PG CBCS syllabus for the year 2015-16 and onwards, the members have been approved the same.
2. The Chairman, BPGS in Statistics placed the list of question setters, examiners, moderators etc. of PG examinations, 2015 (May and December). The members approved the list as proposed.
3. The Chairman, BPGS placed the proposal, submitted by the Supervisors of five Ph.D. scholars namely **Priyanka Talukdar, Ratul Chakraborty, Soma Rani Sutradhar, Khokan Shil and Sharmistha Bhowmik** before the Board for the approval of RAC of individual scholars. After going through the lists of RAC members proposed by respective supervisors, the board approves the individual lists as proposed.

Signature of the Members Present:-

Prof. Sangram Sinha,

Prof. Dilip C. Nath.

Prof. Sudhansu S. Maiti.

Dr. Prasenjit Sinha.

Sri Samrat Hore.

Tripura University (A Central University)
Department of Statistics
Choice Based Credit System MSc Statistics Syllabus

Semester	Code and Name of the Core Courses (Credits)	Code and Elective Courses (Credits)
I	<p>STAT 701C: Measure Theory and Probability (02)</p> <p>STAT 702C: Linear Models (02)</p> <p>STAT 703C: Theory of Distribution (02)</p> <p>STAT 704C: Sample Survey (02)</p> <p>STAT 705C: Practical I and R Programming (04)</p>	<p>STAT 706E: Basic Statistics (04)</p> <p>STAT 707E: Mathematical Analysis (02)</p>
II	<p>STAT 801C: Statistical Inference (04)</p> <p>STAT 802C: Economic Statistics (02)</p> <p>STAT 803C: Industrial Statistics (02)</p> <p>STAT 804C: Practical II (04)</p>	<p>STAT 805E: Demography (02)</p> <p>STAT 806E: Research Methodology (02)</p> <p>STAT 807E: Official Statistics (02)</p>
III	<p>STAT 901C: Multivariate Analysis (04)</p> <p>STAT 902C: Design of Experiments I (02)</p> <p>STAT 903C: Practical III (02)</p> <p>STAT 904C: Project I (04)</p>	<p>STAT 905E: Advanced Sample Survey (02)</p> <p>STAT 906E: Operations Research (02)</p>
IV	<p>STAT 1001C: Stochastic Processes (02)</p> <p>STAT 1002C: Design of Experiments II (02)</p> <p>STAT 1003C: Reliability Theory and Survival Analysis (02)</p> <p>STAT 1004C: Practical IV (02)</p> <p>STAT 1005C: Project II (04)</p>	<p>STAT 1006E: Statistical Decision Theory and Bayesian Inference (02)</p> <p>STAT 1007E: Advanced Time Series and Econometrics (02)</p>

Compulsory Foundation: Computer Skills (Offered by IT and CSE Department) (04)
 Elective Foundation: Yoga/ Song/ Play/Sculpture/NSS/Communicative English (02)

Total Credits Required for Post-Graduation in Statistics: 68 (Sixty Eight)

- One (01) Credit is assigned for each 25 marks and one (01) contact hour/week of teaching for theory or two (02) contact hours/week of teaching for practical/project.
- For each course, 20 % marks are to be allotted for internal assessment.
- All practicals in core courses are to be done using MS Excel, R, SPSS etc.
- Practical classes for electives papers will be conducted in the theory classes. The questions for both practicals and theory will be set in the same question papers.
- Midterm evaluation in every project by seminar.

13/7/15
 Chairman
 B.P.G.S.
 Deptt. of Statistics
 Tripura University

13/7/2015
 Member
 B.P.G.S.
 Deptt. of Statistics
 Tripura University

Approved
 Member
 B.P.G.S.
 Deptt. of Statistics
 Tripura University

13/7/15
 Member
 B.P.G.S.
 Deptt. of Statistics
 Tripura University

The 1st meeting of 2nd BPGS in Statistics was held on 23.02.2017 in the camber of HOD / Coordinator, Department of Statistics, Tripura University at 10.30 am. Members present:

1. Prof. M.K.Singh, Dean, Faculty of Sciences, T.U – Member / Chairman
2. Prof. A. Mukherjee, Department of Mathematics, T.U– Member
3. Dr. Prasenjit Sinha, Assistant Professor, Department of Statistics, T.U – Member
4. Mr. Samrat Hore, Assistant Professor, Department of Statistics, T.U – Member

The chairman welcomed the members. The coordinator of the department informed the members that he had sent invitations to external experts but they were not in a position to attend the meeting. Prof. D. Bhattacharyay, Department of Mathematics, Assam University had expressed his inability to attend the meeting through email. Prof. S.S.Maiti, Department of Mathematics, Visva Bharati Santiniketan had also informed coordinator over telephone. Dr. Saswata Sahoo, Chief Engineer, Advance Tech lab, Samsung R & D Institute, India has informed the coordinator that he may not act as member of BPGS due to some technical problem from his institute.

After this agenda wise discussion were initiated.

Agendum 1: Restructuring of RAC for research scholar, Soma Rani Sutradhar under supervision of Dr. Prasenjit Sinha.

The convener of RAC informed the members that the quorum for RAC meeting could not be materialized as two external members were not available for meeting and one of internal member, Dr. Priyaranjan Dash had left the university to join his new assignment at Utkal University. Under such situation, the convener of RAC felt difficult to do any progress in case of Smt. Soma rani Sutradhar. That is why this agenda has been brought for discussion and fruitful decision.

The matter was discussed and finally Committee resolved to restructure the RAC of Smt Soma Rani Sutradhar as given below.

OLD RAC	NEW RAC
1. Dr. Prasenjit Sinha Assistant Professor, Department of Statistics, T.U – Convener & Supervisor	1. Dr. Prasenjit Sinha Assistant Professor, Department of Statistics, T.U – Convener & Supervisor
2. Prof. Kishore K. Das. Deptt of Statistics, Guawahati University- External Member	2. Dr. Jahar Debbarma. Associate Professor, Deptt. Of Economics, T.U – Member
3. Dr. Jaha Debbarma, Associate Professor, Deptt. Of Economics, T.U – Member	3. Dr. Shyamal Debnath. Assistant Professor, Deptt. Of Mathematics, T.U –Member
4. Prof. R .N Das, Deptt. Of Statistics , University of Burdwan,- External Member	4. Dr. Souvik Bhattacharyay. Assistant Professor, Deptt. Of Mathematics, T.U –Member

Samrat Hore

5. Dr. Priyaranjan Dash., Deptt. Of Statistics ,
Assistant Professor, T.U - Member

5. Prof. R.N Das, Deptt. Of Statistics ,
University of Burdwan.- External
Member

Agendum2: The application of Mr. Khokan Shil, Research Scholar, Deptt of Statistics, T.U

The coordinator, placed the letter of Mr. Khokan Shil. He has stated in his application that he started his Ph.D work with Dr. Priyaranjan Dash but could not registered under him as he left the department to join his new assignment at Utkal University. He has requested to allot a supervisor to him.

The matter was discussed and looking the geniuses of the matter, the committee resolved that Dr. Prasenjit Sinha would be the supervisor of Mr. Khokan Shil as there was no any alternative in the department.

Agendum3: CBCS PG. syllabus related issue (Modification in 3rd semester elective paper and introduction of new elective paper in 3rd semester).

a) The coordinator placed the matter for discussion. Department wanted to propose modification in elective paper, STAT 906E: Operation Research. Earlier this paper was allotted 2-credits but department want to increase the credit-2 to credit-4 for this elective paper (STAT 906E). The matter was discussed and approved. This Matter would be communicated to higher body for necessary action.

b) The department also wants to introduce a new elective paper for 3rd semester course other than two available for students. The matter was discussed and the committee approved the proposal of department to introduce a third elective paper, STAT 907E: Numerical Analysis (02 credits) from the new academic session 2017-2018.

4. Miscellaneous:

a) Approval of RAC for Mr. Khokan Shil: Dr. Prasenjit Sinha (the allotted supervisor) submitted a proposal for formation of RAC for Mr. Khokan Shil and requested to take up the matter as the research scholar passed the pre Ph.D course work in 2014.

The matter was discussed and protecting the interest of student, the proposed RAC was approved by committee. The composition of RAC is given below.

RAC for Khonkan Shil.

1. Dr. Prasenjit Sinha (Deptt of Statistics, TU)- Convener & Supervisor
2. Dr. Salim Sah (Deptt of Economics, TU) - Member
3. Dr. Shyamal Debnath (Deptt of Mathematics, TU) - Member
4. Dr. Souvik Bhattacharya (Deptt of Mathematics, TU) - Member
5. Prof. R.N Das (Deptt of Statistics, Burdwan University, WB) - External Member.

Samsat Hore

b) List of paper setters, examiners and moderators for 2nd semester (May 2016), 1st semester (December 2016), 3rd semester (December 2016), 2nd semester (May 2017) and 4th semester (May 2017).

1. List of paper setters, examiners and moderators. for 2nd semester (May 2016) & 1st semester (December 2016) were reported and approval port facto.
2. List of paper setters, examiner and moderators for 2nd & 4th semester (May 2017) was placed in the meeting. After discussion, the list was approved by the committee with minor modification. The coordinator was requested to send the list to Controller of Examination for necessary action.

The meeting ended with a vote of thanks to the chair.

1.



Chairman
B.P.G.S.
Deptt. of Statistics
Tripura University

2.



Member
B.P.G.S.
Deptt. of Statistics
Tripura University

3.



Member
B.P.G.S.
Deptt. of Statistics
Tripura University

4.



Member
B.P.G.S.
Deptt. of Statistics
Tripura University

SYLLABUS FOR CBCS MSc COURSE IN STATISTICS



TRIPURA UNIVERSITY
(A Central University)
Suryamaninagar, Tripura – 799022.

2017

*BPGS approved syllabus
on 23.02.2017
(1st meeting of 2nd BPGS)
Samant Hore
28/2/17
Co-ordinator,
Department of Statistics,
Tripura University,
Suryamaninagar-799022*

Tripura University (A Central University)
Department of Statistics
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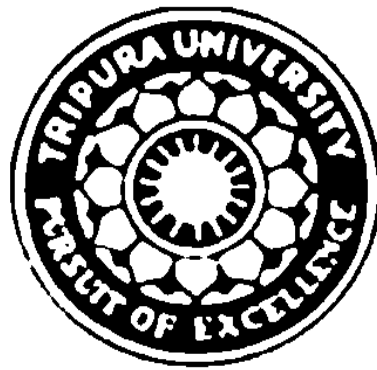
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2. For each course, 30 % marks are to be allotted for internal assessment.
3. All practicals in core courses are to be done using MS Excel, R, SPSS etc.
4. Practical classes for electives papers will be conducted in the theory classes. The questions for both practicals and theory will be set in the same question papers.
5. Midterm evaluation in every project by seminar.

Samant Stone

SYLLABUS FOR CBCS MSc COURSE IN STATISTICS



TRIPURA UNIVERSITY
(A Central University)
Suryamaninagar, Tripura – 799022.

2015

Tripura University (A Central University)
Department of Statistics
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5. Midterm evaluation in every project by seminar.

STAT 701C: Measure Theory and Probability (02)

Classes of sets, fields, sigma-fields, minimal sigma-field, Borel sigma field. Measures and their elementary properties. Measurable functions, Lebesgue measures, Lebesgue-Stieltjes measures and signed measure. Integration, monotone convergence theorem, Fatou's lemma, dominated convergence theorem. Absolute continuity. Radon Nikodym theorem, Product measures, Fubini's theorem.

Basics of probability spaces, random variables, expectations and moments. Basic theorems on probability. Basic, C_r , Markov's, Holder's, Minkowski, Jensen's, Liapounov's, inequalities.

Characteristic function and their elementary properties, moments and applications, uniqueness theorem (statement only), inversion theorem and its applications, continuity theorem, Polya's conditions (statement only), Bochner's theorem(statement only). Bivariate and multivariate characteristic functions.

Convergence of a sequence of random variables: convergence in probability, almost sure convergence, convergence in r^{th} mean and in distribution, their relationship.

Definition of independence, Borel-Cantelli lemma, Borel 0-1 law and Kolmogorov's 0-1 law, Chebyshev's and Khinchine's WLLN, necessary and sufficient condition for the WLLN, Kolmogorov's inequalities (statement only), SLLN and Kolmogorov's theorem.

Central limit theorem, Lindeberg-Levy and Liapunov forms of CLT. Statement of Lindeberg-Feller's CLT and examples.

Suggested Books:

- [1] Ash, R.B. and Doleans-Dade, C.A.: Probability and Measure Theory. Elsevier.
- [2] Sharma, A. K: Measure Theory. Discovery Publishing House.
- [3] Billingsley, P: Probability and Measure. John Wiley.
- [4] Basu, A. K: Measure Theory and Probability. Prentice Hall of India.
- [5] Sen, A. K: Measure and Probability. Narosa Publishing House.
- [6] Laha and Rohatgi: Probability Theory. John Wiley New York.
- [7] Bhat, B.R: Modern Probability Theory. New Age International Publishers.
- [8] Capinski, M. and Zastawniah: Probability Through Problems. Springer.
- [9] Chung, K. L: A Course in Probability Theory. Academic Press, New York.
- [10] Feller, W: An Introduction to Probability Theory and its Applications, Vol I. John Wiley.

STAT 702C: Linear Models (02)

A brief review of linear algebra: vector spaces and matrices, characteristics roots and vectors of square matrices, quadratic forms and their canonical reduction.

Linear statistical models, illustrations, Gauss-Markov model, normal equations and least square estimators, estimable linear functions, g-inverse and solution of normal equations. Error space and estimation space. Variances and covariances of BLUEs. Estimation of error variance, estimation with correlated observations, least squares estimates with restriction on parameters. Simultaneous estimates of linear parametric functions. Fundamental theorems of least squares and applications to the tests of linear hypotheses. Test of hypotheses for one and more than one linear parametric functions. Fisher-Cochran theorem, distribution of quadratic forms. SS of a linear estimate of an estimable function, set of linear estimate, df etc. Sheffe's and Tukey's approach.

Simple and multiple linear regressions, fit of polynomials and use of orthogonal polynomials.

Analysis of Variance - fixed, mixed and random effect models. Analysis of covariance.

Suggested Books:

- [1] Datta, K.E: Matrix and Linear Algebra, Prentice-Hall of India Private Ltd.
- [2] Rao, C.R: Linear Statistical Inference and its Applications, Wiley Eastern Ltd.

- [3] Searle, S.R: Matrix Algebra useful for Statistics, John Wiley, NY.
- [4] Kshirsagar, A M: A Course in Linear Models. Marcel Dekker, N. Y.
- [5] Joshi, D D: Linear Estimation and Design of Experiments. New Age International Publication.
- [6] Mukhopadhyay, P: Mathematical Statistics. Books and Allied (P) Ltd.
- [7] Weisberg, S. Applied Linear Regression. Wiley.
- [8] Chatterjee, S. and Price, B: Regression Analysis by Example. John Wiley, New York.
- [9] Goon, A.M., Gupta, M.K. and Dasgupta, B: An Outline of Statistical Theory, Vol II. The World Press.

STAT 703C: Theory of Distribution (02)

Probability Distribution- Bernoulli, Binomial, Multinomial, Hypergeometric, Poisson, Geometric and Negative binomial distribution, Uniform, Exponential, Cauchy, Beta, Gamma, Normal, t, F and chi-square distributions.

Power series distribution and various distributions as its particular cases. Exponential family of distributions.

Order statistics and their distributions and properties. Joint and marginal distributions of order statistics. Extreme values and their asymptotic distribution (statement only) with applications. Distributions of range, asymptotic distributions of sample median and sample quantiles.

Properties of distribution functions and characteristic functions, marginal and conditional distributions of bivariate discrete and continuous distributions, compound, truncated and mixture of distributions, concepts of convolution.

Suggested Books:

- [1] George Casella and Roger L. Berger: Statistical Inference. Wodsworth & Brooks Pacific Grove, California.
- [2] Johnson, N.L., Kotz, S. and Balakrishnan, N: Discrete Univariate Distributions. John Wiley.
- [3] Johnson, N.L., Kotz, S. and Balakrishnan, N: Continuous Univariate Distributions. John Wiley.
- [4] Mood, M, Graybill, F. A and Bose, D.C: Introduction to the Theory of Statistics. Tata McGraw-Hill, New Delhi.
- [5] Pitman J: Probability Distributions. Narosa Publishing House.
- [6] Dudewicz, E.J. and Mishra, S.N: Modern Mathematical Statistics. John Wiley, New York.
- [7] Rohatgi, V.K: An Introduction to Probability Theory and Mathematical Statistics, Wiley Eastern, New Delhi.
- [1] David, H.A., and Nagaraja, H.N: Order Statistics, Third Edition, John Wiley.
- [8] Arnold, B.C, Balakrishnan, N, and Nagaraja, H.N: A First Course in Order Statistics. John Wiley

STAT 704C: Sample Survey (02)

Basic concepts of finite population and sampling techniques. Simple random sampling – with and without replacements, characteristics and methods of selection, estimation of population mean/total, standard error and its estimate, determination of sample size.

Stratified random sampling – definition, method of selection, estimation of population mean/total with standard error and its estimate, problems of allocations-proportional and optimum, comparison with unrestricted sampling.

Systematic sampling – method of selection, estimation of population mean/total, sampling variance, comparison with simple random sampling and stratified sampling.

Cluster sampling – equal and unequal size, estimation of population mean/total, standard error and its estimation, comparison with mean per unit estimator. Two-stage sampling with equal and unequal first stage units, estimation of population mean/total, standard error and its estimation, comparison with single-stage sampling.

Use of auxiliary information in sample surveys. Methods of estimation – ratio, product, difference and regression methods, sampling variance and efficiency of the estimators.

Suggested Books:

- [1] Cochran, W. G: Sampling Techniques. Wiley Eastern.
- [2] Sampath, S: Sampling Theory and Methods. Narosa Publishing House.
- [3] Singh, Daroga and Chaudhary, F. S: Theory and Analysis of Sample Survey Designs. New Age International (P) Limited Publishers.
- [4] Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling. Prentice Hall.
- [5] Murthy, M. N: Sampling Theory and Methods. Statistical Publishing Society.
- [6] Mukhopadhyay, Parimal: Small Area Estimation in Survey Sampling. Narosa Publishing House.

STAT 705C: Practical I and R Programming (04)

Practical Based on Core Papers of this Semester.

Programming on R:

Data types in R: numeric, character, logical; real, integer, complex, strings and the paste command, matrices, dataframes, lists, setwd, read.table, read.csv, write.matrix, write.csv, creation of new variables, categorisation, cut, factor; round, apply, creation of patterned variables, saving output to a file; source; print, saving workspace/history.

Graphics in R: the plot command, histogram, barplot, boxplot, points, lines, segments, arrows, paste, inserting mathematical symbols in a plot, pie diagram, customisation of plot- setting graphical parameters, text and mtext, the pairs command, colours and palettes, saving to a file; graphical parameters such as mar/mai/mfrow, xlab/ylab/las/xaxp/yaxp/xlim/ylim /cex/axis/tck/srt main/title/legend/locator, identify.

Basic Statistics: r help-command help, help.search(), R mailing list, contributed documentation on cran, one and two sample t tests, bartlett's test for variance, f test for equality of variances, multi sample means, chi squared tests - homogeneity, independence, exact tests and confidence intervals, checking the assumptions, distribution fitting.

Vector matrix operations: matrix operations, addition, subtraction, multiplication, linear equations and eigenvalues, matrix decomposition and inverse, the linear model and qr decomposition, determinant, g inverse, finding a basis, orthonormalisation, finding rank.

Linear models: the lm function; fitting a linear model; anova/ancova/regression models, the summary function, goodness of fit measures, predicted values and residuals; residual plots, the anova table, confidence intervals.

R functions: some useful inbuilt R functions - sort, order, rank, ceiling, floor, round, trunc, signif, apply, lapply, by, programming in R- for/while/if loops, functions, the source command.

Random number generation and simulations: rnorm, rchisq, rt, rbinom etc; sample; set.seed, monte carlo techniques, problems on monte carlo techniques.

Regression: case study from regression analysis.

R libraries: what is an r library? How to load a library? How to use an unknown library? How to get help- documentation and vignettes?

Suggested Books:

- [1] Randall L. Eubank and Ana Kupresanin: Statistical Computing in C++ and R. Chapman & Hall/CRC The R Series.
- [2] Verzani, John. Using R for Introductory Statistics. Taylor & Francis.

STAT 706E: Basic Statistics (04)

Types of statistical data: primary and secondary data, Classification, Tabulation and Diagrammatic representation of data, Frequency Distribution, Cumulative Distribution and their graphical representation, Histogram, Frequency Polygon, Frequency Curve and Ogive.

Measures of central tendency: Arithmetic geometric and harmonic mean, median and mode. Measures of dispersion: Mean Deviation, Variance, moments, skewness and kurtosis and their measures based on quantiles and moments.

Correlation Coefficient and its Properties, Spearman's Rank Correlation Coefficient. Correlation and Regression Analysis, Fitting of Linear equation by the principle of Least Squares. Partial and multiple correlation.

Random Experiments and Random Events, Classical and Axiomatic definitions of Probability (discrete sample space only), Conditional Probability, Independence of Events and Bayes Theorem.

Random Variable and its Probability Distribution, Cumulative Distribution Function, Probability Mass Function and Probability Density Function, Mathematical Expectation, Variance and Moments, Simple Theorems including theorems on expectation and variance of a sum of random variables and expectation of product of Random Variables. Moment generating functions; characteristic functions; probability inequalities (Tchebyshef, Markov, Jensen).

Introduction of some distributions: Bernoulli, Binomial, Poisson, Geometric, Uniform, Normal, Exponential distributions.

Population, sample, Statistic, standard error, estimation, confidence interval and confidence level, confidence interval estimate of proportion and mean. Hypothesis and its types, errors, critical region, level of significance, power and p-values. Test statistics: Student's t-test, Chi-square, F and Z-Statistics and their applications in testing of hypothesis. Exact and Large sample tests. Analysis of Variance.

Non-parametric test - sign, median, run, Mann-Whitney test. Chi square test of goodness of fit, Chi square analysis of contingency table.

Suggested Books:

- [1] Mukhopadhyay, P: Mathematical Statistics. Books and Allied (P) Ltd.
- [2] Mukhopadhyay, P: Applied Statistics. Books and Allied (P) Ltd.
- [3] Goon, A. M. ., Gupta, M. K and Dasgupta, B.: Fundamentals of Statistics; Vol. I, II
- [4] Rohatgi, V.K. and Ehsanes Saleh, A. K. Md. : An introduction to Probability and Statistics

STAT 707E: Mathematical Analysis (02)

Real number system, cluster points of sets, closed and open sets, compact sets, Bolzano-Weierstrass property and Heine-Borel property (statement and use), sets of real vectors.

Sequence, series, convergence, real valued function, limit, continuity, uniform continuity, differentiability of univariate and multivariate functions.

Sequence and series of functions, uniform convergence, power series.

Riemann integral, Riemann Stieltjes integral, Multiple integral.

Complex numbers, Argand diagram, holomorphic functions of a complex variable, Laurent series, Green's theorem, Taylor's theorem, Cauchy's theorem, theory of residues, contour integration.

Suggested Books:

- [1] Goldberg, R. R. : Methods of Real Analysis.
- [2] Burkill , J. C.: First Course of Mathematical Analysis.
- [3] Ahlfors: Complex Analysis.
- [4] Rudin.W: Principles of Mathematical Analysis. Mc Graw Hill
- [5] Malik .S.C. and Arora, S: Mathematical Analysis. Wiley Eastern Ltd.
- [6] Jain, P. K and Kaushik, K. K: An Introduction to Real Analysis. S. Chand.
- [7] Apostol, T.M: Mathematical Analysis. Addison- Wesley.
- [8] Bartle, R.G: Elements of Real Analysis. John Wiley & Sons.
- [9] Berbarian, S.K: Fundamentals of Real Analysis. Springer-Verlag.

STAT 801C: Statistical Inference (04)

Theory of Estimation: Methods of estimation: maximum likelihood method, method of moments, minimum chi-square method, least-squares method. Unbiasedness, efficiency, consistency. Sufficient statistics, Fisher-Neyman factorisation theorem and obtaining sufficient statistic. Minimal sufficient statistics and exponential family, sufficiency and completeness, sufficiency and invariance. Uniformly minimum variance unbiased estimators. Rao-Blackwell theorem and Lehmann-Scheffe theorem. Cramer-Rao lower bound and Bhattacharya system of lower bounds in the single-parameter regular case. Cramer-Rao linequality. Estimation by confidence intervals.

Tests of hypothesis: Simple and composite hypotheses, two types of errors, critical region, review of notions of nonrandomized and randomized tests, level, size, power function, generalized Neyman-Pearson lemma (Sufficiency part only), fundamental Neyman-Pearson lemma (Proof: Existence and Sufficiency parts), UMP Tests. Monotone Likelihood ratio. UMPU Tests, one parameter exponential family (without derivation). Concepts of locally most powerful tests. Similar tests, Neyman structure, UMPU tests for composite hypotheses.

Likelihood ratio test, its properties and its asymptotic distribution. Applications of the LR method. Sequential tests, SPRT and its properties, Wald's fundamental identity, OC and ASN functions. Sequential estimation.

Nonparametric tests: U-statistics, Kernel and systematic kernel. Test for randomness, Sign test, Median test, Mann-Whitney test, Wilcoxon test for one and two-samples, rank correlation and test of independence. Kolmogorov-Smirnov Test, Kruskal-Walli Test, Friedman test.

Suggested Books:

- [1] Kale, B. K: A first Course on Parametric Inference. Narosa Publishing House.
- [2] Rohatgi, V: An Introduction to Probability and Mathematical Statistics. Wiley Eastern. New Delhi (Student Edition).
- [3] Lehmann E. L: Theory of Point Estimation. John Wiley.
- [4] Lehmann, E. L: Testing Statistical Hypotheses. John Wiley.
- [5] Rao, C. R: Linear Statistical Inference and Its Applications. Wiley Eastern.
- [6] Mukhopadhaya, P: Mathematical Statistics. Books and Allied (P) Ltd.
- [7] Wald, A: Sequential Analysis. John Wiley, NY.
- [8] Gibbons, J.D. & Chakraborti, S: Nonparametric Statistical Inference. Marcel Dekker.
- [9] Randles, R.H. and Wolfe, D.A: Introduction to the Theory of Nonparametric Statistics. John Wiley.
- [10] Lehmann, E. L: Nonparametrics: Statistical Methods Based on Ranks. Spinger.
- [11] Conover, W J: Practical Nonparametric Statistics. John Wiley.

STAT 802C: Economic Statistics (02)

Components of time series. Methods of their determination. Variate difference method, Yule-Slutsky effect. Correlogram. Autoregressive models of first and second order. Periodogram analysis.

Index numbers of prices and quantities and their relative merits. Construction of index numbers of wholesale and consumer prices. Income distribution-Pareto and Engel curves. National income and methods of estimating national income. Human Development Index, Poverty Index, Income Inequality measurement and GDI.

Suggested Books:

- [1] Goon, A.M., Gupta, M.K. and Dasgupta, B: Fundamental of Statistics, Vol II. The World Press.
- [2] Mukhopadhaya, P: Applied Statistics. Books and Allied (P) Ltd.

STAT 803C: Industrial Statistics (02)

Control charts for variables and attributes, CUSUM Chart and V-masks; Acceptance sampling by attributes; single, double and sequential sampling plans; OC and ASN functions, AOQL and ATI; Acceptance sampling by variable-use of Dodge-Romig and other tables. Tolerance limits.

Capability indices C_p , C_{pk} and C_{pm} . Estimation, confidence intervals and tests of hypotheses relating to capability indices for normally distributed characteristics.

Suggested Books:

- [1] Montgomery, D. C: Introduction to Statistical Quality Control. John Wiley.
- [2] Wetherill, G B: Sampling Inspection and Quality Control. Halsted Press.
- [3] Wetherill, G B and Brown, D W: Statistical Process Control - Theory and Practice. Chapman and Hall.
- [4] Biswas, S: Statistics of Quality Control, Sampling Inspection and Reliability. New Age International Publishers.
- [5] Mittage, H.J and Rinne, H: Statistical Methods of Quality Assurance. Chapman Hall.
- [6] Balagurusamy, B: Reliability Engineering. Tata Mc Graw Hill.
- [7] Lewis, E E: Introduction to Reliability Engineering. John Wiley.
- [8] Mahajan, M: Statistical Quality Control. Dhanpat Rai & Co Private Ltd., New Delhi.
- [9] Gupta, H.D: Quality assurance through ISO 9000. South Asia Publication, New Delhi.
- [10] Smith, G.M: Statistical Process Control and Quality Improvement. Printice Hall.

STAT 804C: Practical II (04)

Practical Based on Core Papers of this Semester.

STAT 805E: Demography (02)

Sources of demographic data, Rates and ratios of vital events. The life table, its constitution and properties. Makehams and Gompertz curves. Abridged life tables. Stable and stationary populations. Different birth rates. Total fertility rate. Gross and net reproduction rates. Different mortality rates. Standardized death rate. Internal and international migration: net migration. Inter-censal and post-censal estimates. Projection methods including logistic curve, fitting.

Suggested Books:

- [1] Keyfitz, N: Applied Mathematical Demography, Springer Verlag.

- [2] Chattopadhyay, A. K. & Saha, A. K. : Demography: techniques and analysis
- [3] Chiang, C. L. : Introduction to Stochastic Processes in Biostatistics
- [4] Shryock, H. S. et.al.: The Methods and Materials of Demography
- [5] Keyfitz, N.: Applied Mathematical Demography

STAT 806E: Research Methodology (02)

Introduction – Meaning, Importance, Characteristics, Types of Research, Research Process and Research Design.

Selecting a Sample Design. - Sampling Distribution, Principles of Sample Survey, Sampling and Non-Sampling Errors, Types of Sampling, Determination of Sample Size, Types and Collection of Data, Measurement in Research - Types of Measurement Scales, Reliability and Validity, Different Scaling Techniques.

Data Preparation and Processing of Data, Classification and Tabulation, Presentation of Data, Frequency Distribution and Its Characteristics.

Correlation – Simple, Multiple and Partial, Regression Analysis, Test of Significance – Small sample and Large Sample Tests, Cross Tabulation, ANOVA, Multidimensional Scaling Technique, Discriminant Analysis, Factor Analysis, Cluster Analysis, Nonparametric tests.

Report Writing – Framework and Types of a Report, Essentials of a Good Report, Presentation of a Report.

Suggested Books:

- [1] Singh, Y. K.: Fundamental of Research Methodology and Statistics. New Age International.
- [2] Kothari, C. R.: Research Methodology: Methods and Techniques. New Age International.
- [3] Bhuyan, K. C: Multivariate Analysis and Its Applications. New Central Book Agency (P) Ltd.

STAT 807E: Official Statistics (02)

Introduction to 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.

Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India.

System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects.

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Suggested Books:

- [1] Basic Statistics Relating to the Indian Economy (CSO) 1990.
- [2] Guide to Official Statistics (CSO) 1999.
- [3] Statistical System in India (CSO) 1995.
- [4] Principles and accommodation of National Population Censuses, UNESCO.
- [5] Panse, V. G., Estimation of Crop Yields (FAO).
- [6] Family Welfare Yearbook. Annual Publication of D/o Family Welfare.
- [7] Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.

STAT 901C: Multivariate Analysis (04)

Multivariate normal distribution – distribution of linear combination of normally distributed variables, marginal and conditional distributions, distribution of quadratic forms. Random sampling from normal distribution, maximum likelihood estimators of parameters, distributions of sample mean vector and matrix of corrected sum of squares and cross products.

Estimation of partial and multiple correlation coefficients and their sampling distributions (null case only). Hotelling's T^2 statistic – properties, distribution and uses, tests on mean vector for one and more multivariate normal populations and also on equality of the components of a mean vector in a multivariate normal population. Mahalanobis – D^2 statistic and its use.

Classification and discrimination procedures – 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. Fisher's discriminant function.

Wishart matrix – distribution and properties, characteristic function, reproductive property, marginal and conditional distributions. Distribution of sample generalized variance.

Principal components – definition, MLE of principal components and their variances. Canonical variables and canonical correlations – definition, use, estimation and computation.

Suggested Books:

- [1] Anderson, T.W: An introduction to Multivariate Statistical Analysis. John Wiley.
- [2] Giri, N.C: Multivariate Statistical Inference. Academic Press, NY
- [3] Bhuyan, K. C: Multivariate Analysis and Its Applications. New Central Book Agency (P) Ltd.
- [4] Kshirsagar, A.M: Multivariate Analysis. Marcel Decker.
- [5] Rao, C.R: Linear Statistical Inference and Its Application. John Wiley.
- [6] Sharma, S: Applied Multivariate Techniques, John Wiley.
- [7] Srivastva, M.S. and Khatri, C.G: An Introduction to Multivariate Statistics. North Holland.
- [8] Anderson, T.W.: An Introduction to Multivariate Statistical Analysis, 2nd ed., Wiley
- [9] Morrison, D.F.: Multivariate Statistical Methods, 2nd ed., McGraw-Hill

STAT 902C: Design of Experiments I (02)

Design of Experiments: Basic principles of experimental design. Randomisation structure and analysis of completely randomised, randomised blocks and Latin square designs. Analysis of missing plot technique.

Factorial experiments. Analysis of 2^n factorial experiments in randomised blocks.

Split Plot Design, Strip-Plot Design and their applications.

Suggested Books:

- [1] Dey, Alope: Theory of Block Designs. John Wiley.
- [2] Joshi, D D: Linear Estimation and Design of Experiments. New Age International Publication.
- [3] Mukhopadhyay, P: Applied Statistics. Books and Allied (P) Ltd.
- [4] Chakrabarti, M.C: Mathematics of Design and Analysis of Experiments. Asia Publishing House, Bombay.
- [5] Gupta, S.C and Kapoor, V. K: Fundamentals of Applied Statistics. Sultan Chand.
- [6] Das, M.N. and Giri, N.C: Design and Analysis of Experiments. Wiley Eastern.

STAT 903C: Practical III (02)

Practical based on core papers of the current semester.

STAT 904C: Project I (04)

Survey based / Review based report preparation and presentation.

STAT 905E: Advanced Sample Survey (02)

Concept of sampling design, sampling scheme, estimator, sampling strategy, Unequal probability sampling with replacement – probability proportional to size with replacement sampling, estimation of mean/total, method of selection, standard error of estimate and its estimation, comparison with SRSWR, gain due to PPSWR sampling.

Unequal probability sampling without replacement – Des Raj's ordered estimator, Murthy's unordered estimator, Horvitz-Thompson estimator of population mean/total and estimate of variance, Yates-Grundy estimator of variance. Midzuno Scheme of Sampling, and Rao-Hartly-Cochran sampling procedures.

Multi-phase Sampling – Double sampling for ratio and regression methods, Hartley and Ross estimator, Multivariate ratio Estimator (Olkin's estimator).

Problems of finite population inference under a fixed population set up – PDF of data, likelihood function, sufficiency, UMVUE, admissibility, average variance under a model, comparison of strategies. Inference from finite population using prediction theoretic approach - principle, prediction under polynomial and multiple regression models, predicting a super-population mean.

Errors in surveys – types of errors, mathematical models for measurement error. Problems of non response – Hansen and Hurwitz technique, Politz-Simon technique. Randomized response techniques – Warner's model and unrelated question model. Variance estimation – methods of random groups, the Jack knife, balanced half sample, and the bootstrap. Small area estimation – direct, synthetic and composite estimators.

Suggested Books:

- [1] Sukhatme, P.V. and Sukhatme, B.V.: Sampling Theory of Surveys with Applications, Piyush Publications, New Delhi.
- [2] Cochran, W.G.: Sampling Techniques, John Wiley and Sons, New York.
- [3] Singh, Daroga and Chaudhary, F. S: Theory and Analysis of Sample Survey Designs. New Age International (P) Limited Publishers.
- [4] Murthy, M. N.: Sampling Theory and Methods. Statistical Publishing Society.

STAT 906E: Operations Research (02)

Definition and scope of Operations Research, phases in Operations Research, models and their solutions.

Review of linear programming problems, duality in linear programming, duality theorem and dual simplex method. Parametric programming: parameterization of the cost vector 'c', parameterization of requirement vector 'b'. Sensitivity analysis: variation in cost vector 'c', variation in the requirement vector 'b', addition and deletion of single variable and addition and deletion of single constraint.

Integer programming: all integer and mixed programming problem, Gomory's cutting plane method.

Nonlinear programming: Kuhn Tucker conditions, quadratic programming problems, Wolfe's and Beale's methods for solving.

Introduction to decision analysis: pay-off table for one-off decisions and discussion of different decision criteria, decision trees. Decision-making in the face of competition, two-person games, pure and mixed strategies, existence of solution and uniqueness of value in zero-sum games, finding solutions in 2×2 , $2 \times m$ and $m \times n$ games.

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

Replacement problems: block and age replacement policies, replacement of items with long life.
Queuing theory: basic characteristics of queuing models, arrival and service distribution, steady-state solutions of M/M/1 and M/M/C models.
Inventory problems and analytical structure, EOQ formula. Deterministic inventory systems with and without lead-time. Single period stochastic models of inventory controls.

Suggested Books:

- [1] Taha H A: Operational Research - An Introduction. Macmillan.
- [2] Kanti Swarup, Gupta,P.K. and Singh, M.M: Operations Research. Sultan Chand and Sons.
- [3] Sharma, J K: Mathematical Models in Operation Research. Tata McGraw Hill.
- [4] Sinha, S M: Mathematical Programming - Theory and Methods, Elsevier.
- [5] Murthy K G: Linear and Combinatorial Programming. John Wiley.
- [6] Hadley G and Whitin T M: Analysis of Inventory Systems. Prentice Hall.
- [7] Starr, M K and Miller, D W: Inventory Control - Theory and Practice. Prentice Hall.
- [8] Mckinsey, J C C: Introduction to the Theory of Games. McGraw Hill.
- [9] Wagner, H M: Principles of O.R. with Applications to Managerial Decisions. Prentice Hall.
- [10] Gross, D and Harris, C M: Fundamentals of Queueing Theory. John Wiley.

STAT 1001C: Stochastic Processes (02)

Notations and specification of stochastic process, stationary process, martingales, random walk and ruin problems, expected duration of the game, generating function of the duration of the game and for the first passage times, random walk in the plane and space. Markov chains - classification of states and chains, and related problems.

Determination of higher transition probabilities, stability of a Markov system, limiting behavior of finite irreducible chains, ergodic theorem, graph theoretic approach, reducible markov Chains.

Markov processes with discrete state space – Poisson process, properties of Poisson process, Poisson process and related distributions. Generalization of Poisson process – Pure birth process, Yule-Furry process, Pure death process, birth and death processes.

Markov processes with continuous state space – Brownian motion, Wiener process, differential equations for a Wiener process, Kolmogorov equations, first passage time distribution for Wiener process.

Suggested Books:

- [1] Adke, S. and Manjunath, S.M: An Introduction to Finite Markov Process. Wiley Eastern.
- [2] Bhatt, B.R: Stochastic Models - Analysis and Applications. New Age International.
- [3] Medhi, J: Stochastic Process. Wiley Eastern.
- [4] Prabhu, N.U: Stochastic Processes: Basic Theory and its Applications. World Scientific.
- [5] Ross, S.M: Stochastic process. John Wiley and Sons.

STAT 1002C: Design of Experiments II (02)

Incomplete block designs; Balanced, connectedness and orthogonality, BIBD with recovery of inter-block information; Group Divisible Design, PBIBD with 2 associate classes. Quasi-Latin square designs, Youden square design, Lattice design, Mutually orthogonal Latin square (MOLS) design. Analysis of covariance. Analysis of non-orthogonal data.

Factorial experiments, complete confounding and partial confounding.

Optimality criteria for experimental designs.

Design for study of response surfaces; first and second order designs.

Suggested Books:

- [1] Dey, Aloke: Theory of Block Designs. New Age International.
- [2] Dean, Angela and Voss, Daniel: Design and Analysis of Experiments. New Age International.
- [3] Chakrabarty, M.C. : Mathematics of Design of Experiments. Asian pub. House.
- [4] Das, M.N. and Giri, N. : Design and Analysis of Experiments. New Age International.
- [5] Joshi, D.D. : Linear Estimation and Design of Experiments. New Age International.
- [6] Khuri, A. and Cornell, M. : Response Surface Methodology. Marcel Dekker.
- [7] Montgomery, C.D.: Design and Analysis of Experiments. John Wiley, New York.
- [8] Myers, R.H. : Response surface methodology, Allyn and Bacon.

STAT 1003C: Reliability Theory and Survival Analysis (02)

Life distributions, reliability function, hazard rate, mean residual life, common univariate life distributions viz. exponential, gamma, Weibull, lognormal, Rayleigh etc.

Notions of ageing: IFR, IFRA, NBU, DMRL and NBUE classes and their duals and relationships between them, loss of memory property of the exponential distribution.

Series and parallel systems. Reliability concepts and measures, components and systems, coherent systems, reliability of coherent systems.

Estimation of survival function from censored data: Actuarial estimator, Kaplan-Meier estimator.

Regression model for survival data, Cox's proportional hazard model, Accelerated failure time model.

Suggested Books:

- [1] Barlow R.E. and Proschan F: Statistical Theory of Reliability and Life Testing. Rinehart and Winston.
- [2] Nelson, W: Applied Life Data analysis. John Wiley.
- [3] Sinha, S.K: Reliability and Life Testing, Wiley.
- [4] Zacks, S: Reliability Theory. Springer Verlag.
- [5] Biswas, S: Statistics of Quality Control, Sampling Inspection and Reliability. New Age International Publishers.
- [6] R. E. Elandt – Johnson and N. L. Johnson: Survival models and data analysis

STAT 1004C: Practical IV (02)

Practical based on core papers of the current semester.

STAT 1005C: Project II (04)

Final project submission and presentation.

STAT 1006E: Statistical Decision Theory and Bayesian Inference

Game theory and decision theory – composition, decision and risk functions, Nonrandomized Decision Rules, randomization. Optimal decision rules – ordering of the decision rules, geometrical interpretation.

Theorems of decision theory – admissibility and completeness, existence and admissibility of Bayes' rules, existence of a minimal complete class.

The separating hyperplane theorem, essential completeness of the class of non-randomised decision rules, Jensen's inequality, the minimax theorem, the complete class theorems and their applications, solving of minimax rules.

Sufficient statistics, essential complete class of rules based on sufficient statistics, exponential families of distributions, complete sufficient statistics and their applications.

Bayesian estimation – Different loss functions, choice of prior distributions, Point estimation, Bayesian Computation.

Suggested Books:

- [1] Berger, J. O: Statistical Decision Theory and Bayesian Analysis. Springer.
- [2] Ferguson, T. S: Mathematical Statistics - A Decision Theoretic Approach. Academic Press.
- [3] Bansal, A. K: Bayesian Parametric Inference. Narosa Publishing House.
- [4] Box, G.E.P. and Tiao, G.C: Bayesian Inference in Statistical Analysis. Addison and Wesley.
- [5] De. Groot, M.H: Optimal Statistical Decisions. McGraw Hill.
- [6] Sinha, S.K: Bayesian Estimation. New Age International.

STAT 1007E: Advanced Time Series and Econometrics (02)

Time series as discrete parameter stochastic process. Auto covariance and auto correlation functions and their properties. Detailed study of the stationary processes: moving average (MA), auto regressive (AR), ARMA and AR integrated MA (ARIMA) models. Box-Jenkins models. Discussion (without proof) of estimation of mean, auto covariance and auto correlation functions under large sample theory. Choice of AR and MA periods. Estimation of ARIMA model parameters. Spectral analysis of weakly stationary process. Periodogram and correlogram analysis. Forecasting: exponential and adaptive smoothing methods.

Nature of Econometrics. The general linear model (GLM) and its extensions. Ordinary least squares (OLS) estimation and prediction.. Generalized least squares (GLS) estimation and prediction. Heteroscedastic disturbances. Multicollinearity problem, its implications and tools for handling the problem. Ridge regression. Instrumental variable, Use of dummy variables and seasonal adjustment, Errors in variables.

Suggested Books:

- [1] Box, G.E.P and Jenkins, G.M: Time Series Analysis - Forecasting and Control. Holden-day, San Francisco.
- [2] Anderson, T. W: The Statistical Analysis of Time Series. Wiley, N. Y.
- [3] Montgomery, D. C and Johnson, L. A: Forecasting and Time Series Analysis. McGraw Hill.
- [4] Kendall, Sir Maurice and Ord, J. K: Time Series. Edward Arnold, London.
- [5] Brockwell, P.J. and Davis, R.A: Time Series-Theory and Methods. Springer - Verlag.
- [6] Madhani, G. M. K: Introduction to Econometrics - Principles and applications. Oxford and IBH Publising, New Delhi.