First Draft

Course Structure for the Two Years M.Sc. In

STATISTICS

2016

Department Of Statistics
West Bengal State University
Barasat, North 24-Pargans.

Information on the M.Sc. in Statistics Examination

Conventionally a semester consists of 14 weeks and for a course carrying 1 Credit Point (CP), 14 lectures, each with one hour duration, is required.

The 1000 Marks, 80 CP course has been divided into 18 theoretical (700 Marks, 56 CP) and 8 experimental (300 Marks, 24 CP) courses. Experimental sections include Practical, Assignments and Seminar.

For each course, there will be an internal assessment based on a mid-semester examination carrying 20% of the total marks. However, the particulars of the examination (e.g. assessment and reassessment procedures), minimum qualifying marks for a course and for a semester will be in accordance with the existing university regulations.

Courses Offered & Distribution of Marks

Part 1, Semester I

Theoretical Courses (175 Marks, 14 CP)

STA 501 : Mathematical Methods (Linear Algebra & Real Analysis) [50 Marks, 4 CP]
STA 502: Descriptive Statistics (20 Marks), & Probability theory I (30 marks). [50 Marks, 4 CP]
STA 503 : Statistical Inference I (15 Marks), & Sampling distribution I (15 Marks); Survey Methodologies (20 marks). [50 Marks, 4 CP]
STA 504 : Regression Analysis I. [25 Marks, 2 CP]

Practical Courses (75 Marks, 6 CP)

STA 505 : Statistical Computing I [25 Marks, 2 CP]
STA 506 : Practical I [50 Marks, 4 CP]

Examination for STA 505 will be computer based on the topics covered in C and R and STA 506 comprises of practical based on the topics in STA 502-504.

Part 1, Semester II

Theoretical Courses (175 Marks, 14 CP)

STA 511 : Probability Theory II [50 Marks, 4 CP]
STA 512 : Sampling Distribution II (25 marks), & Statistical Inference II (25 marks) [50 Marks, 4 CP]
STA 513 : Linear Models (25 marks), & Regression Analysis II (25 marks) [50 Marks, 4 CP]
STA 514 : Design of Experiments I [25 Marks, 2 CP]

Practical Courses (75 Marks, 6 CP)

STA 515 : Statistical Computing II [25 Marks, 2 CP]
STA 516 : Practical II [50 Marks, 4 CP]

Examination for STA 515 will be computer based on the topics covered in C and R and STA 516 comprises of practical based on the topics in STA 512-514.

Part 2, Semester I

Theoretical Courses (175 Marks, 14 CP)

STA521 : Statistical Inference III (Decision theory & Bayesian Methods I) (25 mar), & Design of Experiments II (25 marks). [50 Marks, 4 CP]
STA522 : Regression Analysis III (25 marks), & Categorical Data Analysis (25 marks) [50 Marks, 4 CP]
STA523 : Statistical Inference IV (Asymptotic Methods, & Nonparametric Theory) [50 Marks, 4 CP]
STA524: Advanced Data Analysis [25 Marks, 2 CP]

Practical Courses (75 Marks, 6 CP)

STA 525 : Statistical Computing III [25 Marks, 2 CP]
STA 526 : Practical III [50 Marks, 4 CP]

Examination for STA 525 will be computer based on the topics covered in C and R and STA 526 comprises of practical based on the topics in STA 521-524.

Part 2, Semester II

Theoretical Courses (175 Marks, 14 CP)

STA 531 : Stochastic Process (30 marks), & Time Series (20 marks) [50 Marks, 4 CP]
STA 532 : Advanced paper I [50 Marks, 4 CP]
STA533 : Advanced Paper II [50 Marks, 4 CP]
STA 534 : Applied Multivariate Analysis [25 Marks, 2 CP]

Practical Courses (75 Marks, 6 CP)

STA 535 : Project Work [25 Marks, 2 CP]
STA 536 : Practical I [50 Marks, 4 CP]

Examination for STA 526 comprises of practical based on the topics in STA 531-534.

Selection of the Advanced Papers (STA 532-533)

For the selection of advanced papers (STA 532-533), students need to select any two of the following four modules and the courses thereof. However, the modules, as well as the optional papers within each module, to be offered in a particular year, will be decided by the Department.

Module 1: Survival Analysis and Bayesian Inference & Applications
Survival Analysis (25 marks); Bayesian Inference & Applications (25 marks)

Module 2: Advanced Survey Sampling
Advances Sample Survey (25 marks); Model-Dependent Inference In Survey Sampling (25 marks)

Module 3: Industrial Statistics
Operations Research (25 marks); Optimization (25 marks)

Module 4: Econometrics and Financial Statistics
Advanced Econometric Methods (25 marks); Statistics in Finance (25 marks)

\

DETAILED SYLLABUS

Part 1, Semester I [STA 501-506]

STA 501: Mathematical Methods

Linear Algebra

Vector spaces with real field. Basis dimension of vector space. Orthogonal vectors, Gram-Schmidt orthogonalization. Linear transformation of matrices. Matrix operations. Elementary matrices and their uses. Rank of a matrix and related results. Inverse of a matrix. Determinants. Characteristic roots and vectors. Quadratic forms-classification and canonical reduction. Singular value decomposition. System of linear equations: homogenous and non-homogenous system. Generalized inverse: Moore-Penrose. Idempotent matrices and its properties. [15]

References

G. Hadley :Linear Algebra
K. M. Hoffman, & R. Kunze :Linear algebra
F.E. Graybill :Introduction to Matrices with Applications in Statistics
F. E. Hohn :Elements of Matrix Algebra
C. R. Rao :Linear Statistical Inference and Its Applications
S. R. Searle :Matrix Algebra Useful for Statistics
A.M. Goon :Vectors and matrices

Real Analysis

Real number system, cluster points of sets, closed and open sets, compact sets, Bolzano-Weierstrass property and Heine-Borel property-statement and applications. Sequences and Series of functions : pointwise convergence, uniform convergence, absolute convergence. Some tests of convergence. Continuity, uniform continuity, differentiability of univariate and multivariate functions. Mean value Theorem. Reimann integral and its properties. Reimann-Stieltjes integral. Review of sequence and series of functions. Uniform convergence: term by term differentiation and integration Power series. Taylor series expansion. [35]

References

T.M. Apostal :Mathematical analysis
R. Rudin :Principles of Mathematical Analysis

R.R.Goldberg : Methods of Real Analysis
J.C.Burkill : First Course of Mathematical Analysis
J.C.Burkill, & H.Burkill : Second Course of Mathematical Analysis
R.G. Bartle, & D.R. Sherbert : Introduction to Real Analysis

STA 502: Descriptive Statistics & Probability theory I

Descriptive Statistics

Introduction to Descriptive statistics. Univariate data – different measures of location, dispersion, relative dispersion, Skewness and kurtosis. Moments. Quantiles and measures based on them –comparison with moment measures. Gini's coefficient. Lorenz curve. Box Plot. Bivariate data – scatter diagram, correlation coefficient and its properties. Correlation ratio . Correlation Index. Intraclass correlation with equal and unequal group sizes. [20]

References

A.M. Goon, M.K. Gupta , & B. DasGupta. :Fundamentals of Statistics (vol.1)
G.U. Yule, & M.G. Kendall. :An introduction to the Theory of Statistics.
M.G. Kendall, & A. Stuart. : Advanced Theory of Statistics (vols. 1-2)
G. W. Snedecor, & W.G. Cochran :Statistical Methods
F.F. Croxton, D.J. Cowden, & S. Klein. :Applied General Statistics,
F.E. Wallis, & H.V. Roberts :Statistics-a new approach.
J.W. Tukey :Exploratory Data Analysis
M.S. Lewis Beck (ed.) :Regression Analysis

Probability Theory I

Random Variables : Definition of discrete and continuous random variables. Cumulative distribution function and its properties (with proof), probability mass function and probability density function. Expectation and Moments, Dispersion, Skewness, Kurtosis, Quantiles. The cumulative distribution function, probability mass function and probability density function in bivariate case. Marginal and Conditional distributions. Independence. Conditional Expectation. Correlation and Regression. Generating Functions : probability generating function and moment generating function in univariate and bivariate cases. Probability Inequalities : Chebyshev's lemma, Markov's & Chebyshev's inequalities. Some univariate distributions. Bivariate Normal distributions and its properties. Limit Theorems : Convergence in probability, Weak law of large numbers and its applications. Convergence in distribution. De-Moivre-Laplace limit

theorem, Normal approximation to the Poisson distribution. Statement of Central limit Theorem (independent and identically distributed sequence of random variables) and its application. [30]

References

K.L. Chung. :Elementary Probability Theory with Stochastic Process.
W. Feller :An introduction to Probability Theory & its application (vol. 1)
A.M. Goon, M.K. Gupta , & B. DasGupta. :An Outline of Statistical Theory (vol. –1)
V.K. Rohatgi, & Md. E. Saleh. : An Introduction to Probability and Statistics
P.J. Hoel , S.C. Port, & C.J. Stone. :Introduction to Probability Theory (vol. 1)
G.C. Casella, & R.L. Berger. Statistical Inference
H. Cramer. :The Elements of Probability Theory
E. Parzen. : Modern Probability Theory and Its Application
J.V. Uspensky :Introduction to Mathematical Probability and Its Application
T. Cacoullos. : Exercises in Probability
N.A. Rahman. : Practical Exercises in Probability and Statistics
J. Pitman. : Probability
D. Stirzaker. : Elementary Probability
T.K. Chandra, & D. Chatterjee. : A First Course in Probability
R.R. Bhat : Modern Probability Theory
A. Gut. : An Intermediate Course In Probability
A. Dasgupta. : Fundamentals of Probability: A First Course

STA 503: Sampling distribution I , Statistical Inference I, & Survey Methodologies.

Sampling Distribution I

Introduction : Concepts of random sampling. Statistic and its sampling distribution. Illustrations using different distributions, reproductive properties of the distributions. Some standard Sampling Distributions : χ^2 distribution, distributions of the mean and variance of a random sample from a normal population, t and F distributions, distributions of means, variances and correlation coefficient (null case) of a random sample from a bivariate normal population, distribution of simple regression coefficient (for both stochastic and non-stochastic independent variable cases). Distribution of order statistics and sample range. [15]

References

A.M. Goon, M.K. Gupta , & B. Das Gupta. : Fundamentals of Statistics (vol.1)
A.M. Goon, M.K. Gupta , & B. Das Gupta. : Outline of Statistics (vol.1)
C. R. Rao. : Advanced Statistical Methods In Biometric Research
R.V. Hogg, A.T Craig. :Introduction to Mathematical Statistics
G. Stuart, J.K. Ord : Advanced Theory of Statistics (vol. 2)
E.S. Keeping :Introduction to Statistical Inference.
G.K. Bhattacharya, & R.A. Johnson R.A.: Concepts & Methods Of Statistics
V.K. Rohatgi, & Md. E. Saleh. : An Introduction to Probability and Statistics
N.I. John, S. Kotz. :Distributions in Statistics
S.M. Ross. : Introduction to Probability Models.
A.M. Mood, F. Graybill, & D.C. Boes. : An Introduction to the Theory of Statistics

Statistical Inference I

Data reduction : Sufficiency and minimal sufficiency, Completeness, Bounded completeness and Ancillary Statistic. Exponential family of distributions.

Point Estimation: Concepts of point estimation. Requirement of a good estimator-notions of mean square errors., unbiasedness and minimum variance. Minimum variance unbiased estimators : Cramer-Rao lower bound, Rao-Blackwell, and Lehmann-Scheffe theorems. [15]

References

E. L. Lehmann, & G. Cesella. : Theory of Point Estimation
G.C. Casella, & R.L. Berger. Statistical Inference
S. Zacks. : Theory of Statistical Inference
S.S. Wilks. : Mathematical Statistics
V.K. Rohatgi, & Md. E. Saleh. : An Introduction to Probability and Statistics
A.M. Goon, M.K. Gupta , & B. DasGupta. :An Outline of Statistical Theory (vol. 2)
Nitis Mukhopadhyay. : Probability and Statistical Inference
R. W. Keener. : Theoretical Statistics: Topics for a Core Course

Survey Methodologies

Probability sampling from a finite population Basic sampling schemes : equal and unequal probability sampling with/without replacement. Related estimators of population total/mean, their variances and variance estimators. Horvitz Thompson, Hansen Horvitz, Des Raj and Murthy's estimator. Stratified sampling : allocation problem & the basic idea of optimal allocation, construction of strata. Basic ideas of Ratio, Product, Difference and Regression estimators. Unbiased Ratio type estimators. Hartley-Ross estimator in

simple random sampling. Sampling and sub-sampling of clusters. Two-stage sampling, and double sampling. [20]

References

W.G. Cochran. : Sampling Techniques
Des Raj. : Sampling Theory
A.S.Hedayat & B.K.Sinha. :Design & inference in finite population sampling
P. Mukhopadhyay. : Theory & Methods of Survey Sampling
P. S. Levy, & S. Lemeshow. : Sampling of Populations: Methods and Applications
S. K. Thompson. : Sampling

STA 504 : Regression Analysis I

Simple Regression-related results. Multiple regression. Multiple correlation and partial correlation and their properties. Introduction : heterogeneity and analysis of variance (ANOVA) & covariance (ANCOVA). Linear hypothesis, orthogonal splitting of total variance, and selection of valid Error. Applications of the ANOVA technique : one-way classified data, two-way classified data with number of observations per cell, testing simple regression coefficients, correlation ratio, linearity of simple regression, multiple correlation and partial correlation coefficients. [25]

References

N. R. Draper, & H. Smith. : Applied Regression Analysis
A.M. Goon, M.K. Gupta , & B. DasGupta. :Fundamentals of Statistics (vols.1-2)
H. Sheffe : The Analysis of Variance
H. Sahai : The Analysis of Variance: fixed, random, and mixed models.
M.G. Kendall, & A. Stuart. : Advanced Theory of Statistics (vol. 3)
A.M. Dean, & D. Voss : Design and Analysis of Experiments
O. Kempthrone :The Design and Analysis of Experiments
W.G. Cochran, & G. M. Cox. : Experimental Designs
D.C. Montgomery. : Design and Analysis of Experiments
P. Mukhopadhyay. : Applied Statistics
D.G. Montgomery, E.A. Peck, & G.G. Vining. : Introduction to Linear Regression Analysis

STA 505 : Statistical Computing I

Computing with C : A brief overview of C: Syntax, loops, pointers, arrays, structures, functions, files. Review of statistical programming in C.
Computing with R : Basic operations: Basic arithmetic operations (addition, subtraction, multiplication, division etc): Use of R as a scientific calculator. Graphical display: Stem-leaf plot, Histogram and Density plot, Box plot, Scatter plot. Descriptive statistics: Simple Descriptive Measures (mean, variance, sum of squares, maximum, minimum, quantiles, correlation coefficient). Sample drawing techniques: Drawing of random numbers, SRS procedure-with and without replacements..Matrix Calculations: Vectors and matrices: Basic operations on vector and matrices (addition, multiplication, calculation of quadratic forms).Determinant, Trace, Rank, Inverse and Solution of linear equations. Eigenvalues and Eigenvectors of a square symmetric matrix. Spectral Decomposition, Choleski Decomposition, Singular Value Decomposition of any matrix and rank determination. Moore-Penrose Generalized inverse using Singular Value Decomposition. [25]

References

B. W. Kernighan, & D.M. Ritchie. : The **C** Programming Language
H. Kanitkar. : Let us C
W. N. Venables and B. D. Ripley : Statistics: An introduction using R
Michael J. Crawley : Statistics: An introduction Using R
A. de Vries, & J. Meys. : R for Dummies.
K. Baclawski. : Introduction to Probability With R
A. Zuur, E.N. Leno, & E. Meesters. : A Beginner's Guide to R
P. Dalgaard. : Introductory statistics with R.

STA 506 : Practical I

Practical exercises related to topics in STA 502-504. [50]

Part 1, Semester II [STA 511-516]

STA 511: Probability Theory II

Borel fields and sigma fields in probabily. Probability as a measure. Measurable functions: random variable as a measurable function. Integration of a measurable function with respect to a measure. Sequence of measurable functions: Monotone convergence theorem, Fatou's lemma and Dominated convergence theorem and their probabilistic aspects. Radon-Nikodym theorem (statement and application). Distribution functions: application of Lebesgue-Stieltje's measure. Expectation. Generating functions and Characteristic function. Inversion theorem and Continuity Theorem (only statement).

Independence: Borel Cantelli Lemma. Sequence of random variables. Different modes of convergence of a sequence of random variables-inter-relations, Weak and Strong laws of large numbers. Kolmogorov's inequality. Central limit theorems (statement and applications). [50]

References

J. Jacod, & P. Protter. :Probability Essentials
K. B. Athereya, & S.N. Lahiri. : Measure Theory
K. B. Athereya, & S.N. Lahiri. : Probability Theory
A.K.Basu. : Measure Theory and Probability
B.R.Bhat. : Modern Probability Theory
P.Billingsley. : Probability and Measure
J.F.C. Kingman, & S.J. Taylor. : Introduction to Measure and Probability
R.G.Laha, & V.K. Rohatgi. : Probability theory
R. Ash. : Real Analysis and Probability
A. Gut : Probability : A Graduate Course
G. Grimmett, & D. Stirzaker. : One Thousand Exercises in Probability.

STA 512: Sampling Distribution II, & Statistical Inference II

Sampling Distribution II

Concepts of non central distributions: χ^2, t and F. General discussion on multivariate distributions. Multivariate normal distribution and related results. Distribution of quadratic forms, Cochran's theorem. Random sampling from a multivariate normal distribution: Wishart matrix and its distribution (without derivation) and properties. Hotelling T^2 statistics: its distribution and related results. Mahalanobis D^2 statistics. [25]

References

C. R. Rao. : Linear Statistical Inference and Its Applications
T. W. Anderson. : Introduction to Multivariate Analysis
S. S. Wilks. : Mathematical Statistics
A. M. Khirsagar. : Multivariate Analysis
C.G. Khatri, & M.S. Srivastava. : Introduction to Multivariate Statistics
R. J. Muirhead. : Aspects of Multivariate Statistical Theory
G. A. F. Seber. : Multivariate Observations
M. Bioodeau, & D. Brenner. : Theory of Multivariate Statistics

Statistical Inference II

Testing Of Hypothesis Nonrandomized and Randomized tests, critical function, power function. Most Powerful (MP) Tests: Neyman-Pearson Lemma (Existence, Sufficiency and Necessity). Uniformly most powerful (UMP) tests: simple problems for exponential and pitman families of distributions. Enlargement technique for testing a composite null against a composite alternative. UMP tests for monotone likelihood ratio (MLR) families. Generalised Neyman-Pearson Lemma: uniformly most powerful unbiased (UMPU) tests for one parameter exponential families. Ideas of similar tests.

Sequential Analysis Sequential Probability ratio test (SPRT). Wald's equation (without proof). Optimality of SPRT. Wald's fundamental identity (without proof). SPRT of one sided test.

Confidence Interval Estimation Relation with hypothesis testing. Optimum parametric confidence intervals. [25]

References

E. L. Lehmann, & J. P. Romano. : Testing Statistical Hypotheses
G.C. Casella, & R.L. Berger. Statistical Inference
S. Zacks. : Theory of Statistical Inference
S.S. Wilks. : Mathematical Statistics
V.K. Rohatgi, & Md. E. Saleh. : An Introduction to Probability and Statistics
A.M. Goon, M.K. Gupta , & B. DasGupta. :An Outline of Statistical Theory (vol. 2)
Nitis Mukhopadhyay. : Probability and Statistical Inference
R. W. Keener. : Theoretical Statistics: Topics for a Core Course

STA 513: Linear Models, & Regression Analysis II

Linear Models

Gauss-Markov model. Estimable functions. Best linear unbiased estimator (BLUE). Gauss Markov Theorem. Estimation space and error space. Sum of squares due to a set of linear functions. Estimation with correlated observations. Least Square estimation with linear restriction on the parameters. General linear hypothesis: *F* test for general linear hypothesis and associated confidence sets. Multiple comparison procedures of Scheffe and Tukey. Applications of general linear hypothesis to regression. Analysis of variance and covariance (ANOVA & ANCOVA). Introduction to random and mixed effect models (balanced case). [25]

References

H. Scheffe. : Analysis of Variance
S. R. Searle. : Linear Models
G. A. F. Seber, & A.J. Lee. : Linear Regression Analysis
N. Giri. : Analysis of Variance
D. D. Joshi. : Linear Estimation & Design of Experiments
C. R. Rao. : Linear Statistical Inference and its Applications
R. B. Bapat. : Linear Algebra and Linear Models
R. W. Keener. : Theoretical Statistics: Topics for a Core Course

Regression Analysis II

Regression with one explanatory variable. Direct, reverse, orthogonal, and least absolute deviation (LAD) regressions with applications. Weighted least squares technique. Tests of fit of a model. Detection of outliers. Residual analysis: residuals and their plots. Departures from the usual assumptions: heteroscedasticity, autocorrelation, multicollinearity, Non-normality- detection and remedies. Model selection.

[25]

References

H. Scheffe. : The Analysis of Variance
A. Sen, & M. Srivastava.: Regression Analysis: Theory, Methods, and Applications
S. Chatterjee, & A. S. Hadi. : Sensitivity Analysis in Linear Regression
S. Chatterjee, & A.S. Hadi. : Regression Analysis by Example
S. Weisberg. : Applied Linear Regression
J. Fox. : Regression Diagnostics: An Introduction
D. A. Belsley, E. Kuh, & R. E. Welsch. : regression Diagnostics: Identifying Influential Data and Sources of Collinearity.
S. R. Searle. : Linear Models
G. A. F. Seber. : Linear Regression Analysis
N. Giri. : Linear Estimation & Design of Experiments

STA 514: Design of Experiments I

Basic principles of experimental design: randomization, replication, and local control. Uniformity trials. Shapes and sizes of plots and blocks. Standard designs and their analyses : completely randomised design (CRD), randomised block design (RBD), latin square design (LSD), split plot design, and strip arrangements. Comparison of efficiencies. Applications of the techniques of analysis of variance to the analysis of the above designs. Groups of experiments using RBD and LSD. General block designs and its information matrix. Concepts of connectedness, orthogonality, and balance. Intrablock analysis of orthogonal (CRD, RBD, LSD) and non-orthogonal designs (Balanced

incomplete block design (BIBD), and Youden square design (YSD)). Recovery of interblock information in BIBD. [25]

References

O. Kempthrone. : The Design and Analysis of Experiments
M. N. Das, & N. C. Giri. : Design and Analysis of Experiments
D. C. Montgomery. : Design and Analysis of Experiments
W. G. Cochran, G.M. Cox. : Experimental Designs.
W. T. Federer. : Experimental Designs – Theory and Application
A.M. Goon, M.K. Gupta , & B. DasGupta. :Fundamentals of Statistics (vol. 2)
A.M. Dean, & D. Voss : Design and Analysis of Experiments
M. C. Chakraborty. : Mathematics of Design and Analysis of Experiments
A. Dey. : Theory of Block Designs
D. Raghavarao. : Constructions & Combinatorial Problems in Design of Experiments
R. C. Bose. : On the Construction of Balanced Incomplete Block. (Annals Eugenics, vol. 9)

STA 515: Statistical Computing II

Computing in C Stochastic simulation: generation of random numbers and selection of samples, and Monte Carlo simulation.

Computing with R Data manipulation : built-in datasets in R, read.table() and write.table() functions, and importing data from external sources. The built-in distributions in R : c.d.f., p.d.f./ p.m.f. , densities, quantiles, and random samples. Statistical inference: one sample and two sample problems, ANOVA, Goodness of fit tests. Regression Analysis: multiple linear regression using `lm()` function and related inferences and diagnostics. Weighted least squares. Measures of identifying unusual observations using in-built R functions (influence.measures(), dfbetas(), dffits(), cook.distance()). Box-Cox Transformation, Q-Q plot, Shapiro-Wilk Test. [25]

References:

B. W. Kernighan, & D.M. Ritchie. : The **C** Programming Language
H. Kanitkar. : Let us C
R. Chakraborty. : Statistical Analysis using C: The Art of Statistical Computing.
W. H. Press et al. : Numerical Recipes Using C : The Art of Scientific Computing
J. F. Faraway. : Linear Models with R
J. F. Faraway.: Practical Regression and ANOVA Using R
J. Fox., & S. Weisberg. : An R Companion To Applied Regression

STA 516: Practical II

Practical exercises related to topics in STA 512-514. [50]

Part 2, Semester I [STA 521-526]

STA 521: Statistical Inference III, & Design of Experiments II

Statistical Inference III : Decision Theory

Loss, Decision rules and Risk function, Admissibility of decision rules, Bayes and Minimax rules. [10]

Statistical Inference III : Bayesian Methods

Overview and comparison of different paradigms, Relative advantages and disadvantages. Priors & Posteriors : Subjective priors, Conjugate and other Non-subjective priors. Bayesian Inference – estimation, testing, interval estimation and prediction for some common models and common priors. Hierarchical and Empirical Bayes Methods. Bayesian Computation. [15]

References

T.S. Ferguson. : Mathematical Statistics
E. L. Lehmann, & G. Cesella. : Theory of Point Estimation
J. O. Berger. : Statistical Decision Theory and Bayesian Analysis
H. Raiffa. : Applied Statistical Decision Theory
J. Pratt, & H. Raiffa. : Introduction To Statistical Decision Theory
F. Liese., & K.-J. Miescke. : Statistical Decision Theory
P. D. Hoff. : A First Course in Bayesian Statistical Methods
G. E. P. Box, & G. C. Tiao. : Bayesian Inference in Statistical Analysis
W. M. Bolsted. : Introduction to Bayesian Statistics
L. Held., & D. S. Bove. : Applied Statistical Inference: Likelihood and Bayes.
J.-M. Marin, & C.P. Robert. : Bayesian Essentials with R
J. Albrt. : Bayesian Computation with R

Design of Experiments II

Construction of complete classes of Mutually Orthogonal Latin Squares (MOLS).Construction of BIBD using MOLS and Boses's fundamental method of difference. Factorial experiment: Confounding and balancing in symmetric factorial experiments- Analysis. [25]

References

M. C. Chakraborty. : Mathematics of Design and Analysis of Experiments

A. Dey. : Theory of Block Designs
D. Raghavarao. : Constructions & Combinatorial Problems in Design of Experiments
R. C. Bose. : On the Construction of Balanced Incomplete Block. (Annals Eugenics, vol. 9)
R. C. Bose. : Mathematical Theory of Symmetric Factorial (Sankhya, Vol. 8)

STA 522: Regression Analysis III, & Categorical Data Analysis

Regression Analysis III

Generalized Linear Models (GLM): Introduction, components, goodness of fit measures-residuals and deviance. Inference for GLM. Applications to binary, count and polytomous data. Over dispersion. Marginal, conditional and quasi likelihood functions. Robust regression. [25]

References

P. McCullagh, & J. L. Nelder. : Generalized Linear Models
A. Dobson, & A. Barnett. : An Introduction to Generalized Linear Models
J. K. Lindasy. : Applying Generalized Linear Models
C. E. McCullagh, S.R. Searle, & J. M. Neuhaus.: Generalized, Linear, and Mixed Models
J. J. Faraway. : Extending the Linear Model with R
A. Agresti. : Foundations of Linear, and Generalized Linear Models

Categorical Data Analysis

Categorical Response Data: Nominal/ Ordinal Distinction, Probability Distributions for Categorical Data-Binomial& Multinomial Distributions. Inference for a proportion: Wald, Score, and Likelihood-Ratio Inference for Binomial Parameter. Contingency Tables**:** Probability Structure for Contingency Tables: Joint, Marginal, and Conditional Probabilities, Relative risk and odds ratio-properties. Measures of association and tests for independence in contingency tables: Nominal-Nominal, Ordinal – Ordinal and Nominal–Ordinal Tables. Exact Inference for Small Samples- Fisher's Exact Test for 2×2 Tables. Association in more than two-way classified data: Partial association, Conditional Versus Marginal Associations- Simpson's Paradox, Conditional and Marginal Odds, log-odds ratio and its distribution, Independence-Conditional Versus Marginal. [25]

References

A. Agresti. : Categorical Data Analysis
A. Agresti. : Analysis of Ordinal Categorical Data
A. Agresti. : Introduction to Categorical Data Analysis
J. S. Simonoff. : Analyzing Categorical Data

STA 523: Statistical Inference IV

Asymptotic Methods

Large sample properties of estimators: Consistency, Efficiency and Asymptotic Normality-CAN and BAN estimators. Maximum likelihood method of estimation (MLE) - Large sample properties. Likelihood ratio, Rao and Wald tests for simple and composite hypotheses- properties and asymptotic distribution of test criteria in the simple hypothesis case. [25]

References

E. L. Lehmann. : Elements of Large-Sample Theory
E. L. Lehmann, & G. Cesella. : Theory of Point Estimation
T. S. Ferguson. : A Course in Large Sample Theory
P. K. Sen, & Singer. :Large Sample Methods in Statistics: An Introduction with Application
R. J. Serfling. : Approximation Theorems in Mathematical Statistics.
A. C. P. de Lima, J. M. Singer, & P. K. Sen. : From Finite sample To Asymptotic Methods in Statistics.
T. K. Chandra. : A First Course in Asymptotic Theory of Statistics
J. Jiang. : Large sample Techniques for Statistics
A. Dasgupta. : Asymptotic Theory of Statistics and Probability
D. D. Boos, & L L. Stefanski. : Essential Statistical Inferenc: Theory and Methods
R. W. Keener. : Theoretical Statistics: Topics for a Core Course

Nonparametric Theory

U-statistics- Definition and Asymptotic properties. Nonparametric tests: Single sample Problems: Location, Location-cum-symmetry, and Goodness-of-fit problems. Two-sample Problems: Location, Scale and Homogeneity problems. Multi-sample location problem. Friedman Two-way Analysis of variance problem. Bivariate association problem, Cochran Q-test for dependent samples. Nonparametric Interval Estimation. Concept of Asymptotic Relative Efficiency. Nonparametric Density Estimation. [25]

References

J. D. Gibbons. : Nonparametric Inference
J. D. Gibbons, & S. Chakraborty. : Nonparametric Statistical Inference
T. P. Hettmansperger. : Statistical Inference Based on Ranks

E. L. Lehmann. : Statistical Methods based on Ranks
M. Hollander, D. A. Wolfe, & E. Chicken. : Applied Nonparametric Statistics
P. Sprent, & N. C. Smeeton. : Applied Nonparametric Statistical Method
S. Bonnini et al. : Nonparametric Hypothesis Testing
L. Wasserman. : All in Nonparametric Statistics

STA 524: Advanced Data Analysis

Longitudinal Data Introduction with motivation, Exploring longitudinal Data with some specific dependence structure

Missing data mechanism Inference for data with missing values. Different types of missing data mechanism. MLE using E-M algorithms. Various imputation techniques.

Re-sampling Techniques- Introduction to Jackknife and Bootstrap – methods for estimating bias ,standard error and distribution function based on i.i.d. random variables. Standard examples. Justification of the methods in i.i.d. set-up, Bootstrap confidence intervals, Computational aspects. [25]

References

P. Diggle et al. : Analysis of Longitudinal Data
G. Fitzmaurice, N. M. Laird, & J. H. Ware. : Applied Longitudinal Analysis
R. E. Weiss. : Modeling Longitudinal Data
D. Hedeker, & R. D. Gibbons. : Longitudinal Data Analysis
R. J. A Little, & D. B. Rubin. : Statistical Analysis with Missing Data
P. A. Allison. : Missing Data
C. K. Enders. : Applied Missing Data Analysis
D. F. Heitjan, & S. Basu. : Distinguishing "Missing at Random" and "Missing Completely at Random" (The American Statistician, Vol. 50)
T. Raghunathan. : Missing Data Analysis in Practice
B. Efron & R. J. Tibshirani. : An Introduction to the Bootstrap
A. C. Davison, & D.V. Hinkley. :Bootstrap Methods and Their Applications
J. Shao, & D. Tu. : The Jackknife and Bootstrap
M. R. Chernick, & R. A. LaBudde. : An Introduction to Bootstrap Methods with Applicatiosn to R

STA 525: Statistical Computing III

Advanced Computing with C Numerical methods (Iteration, Newton-Raphson, Quasi-Newton algorithms) with C.

Advanced Computing with R Creating user defined functions: Conditional statements, loops, arrays. Numerical optimization: Solution of numerical equations (single unknown)- Maximum Likelihood Estimates, Nonlinear regression(nls() and nlm() functions). Numerical Integration: Numerical evaluation of probabilities involving one and two random variables. Simulation: Simulating functions of random variables.

References

W. H. Press et al. : Numerical Recipes Using C : The Art of Scientific Computing
V. A. Bloomfield. : Using R for Numerical Analysis in Science and Engineering
N. Matloff. : The Art of R Programming

STA 526: Practical III

Practical exercises related to topics in STA 521-524.

Part 2, Semester II [STA 531-536]

STA 531: Stochastic Process, & Time Series

Stochastic Process

Markov chain with finite state space and countable state space, Classification of states, Chapman-Kolmogorov equation, Calculation of n-step transition probability matrix and its limit, Stationary distribution of Markov chain, Random walk. Discrete state space continuous time Markov chains, Poisson process. Renewal theory: Elementary Renewal theorem, Stopping time, Statement and uses of Key Renewal theorem. Continuous process: Brownian motion. [30]

References

S. Karlin, & H. M. Taylor. : A First Course in Stochastic Processes
S. Ross. : Stochastic Process
J. L. Doob. : Stochastic Process
J. Medhi. : Stochastic Process
A. K. Basu. : Stochastic Process
P. G. Hoel, S. C. Port, & C. J. Stone C.J . : An Introduction to Stochastic Process
D. R .Cox. : Renewal Theory

Time Series Analysis

Stationary Time Series, linear process, causality and Invertibility, properties of linear stationary process, autocovariance function (ACVF) and partial autocorrelation function (PACF), methods of finding ACVF, ARMA process as particular case. Forecasting a time series, Best linear unbiased predictor, Iterative methods (Durbin - Levinson and Innovations Algorithm) of finding predictor with ARMA process as a particular case. [20]

References

C. Chatfield. : The Analysis of Time Series - An Introduction

G. E. P.Box, G. M. Jenkins & G.C.Reinsel. : Time Series Analysis - Forecasting and Control

G. Jancek & L. Swift. : Time Series - Forecasting, Simulation, Applications

P. J. Brockwell & R. A. Davis. : Introduction to Time Series and Forecasting

P. J. Brockwell & R. A. Davis. : Time Series: Theory and Methods

P.S. P. Cowpertwait & A.V. Metcalfe. : Introductory Time Series with R

R.H. Shumway & D. S. Stoffer. : Time Series Analysis & Its Applications

J.D. Cryer & K.-S. Chan. : Time Series Analysis: with Application in R

STA 532: Advanced Paper I

STA 533: Advanced Paper II

STA 534: Applied Multivarite Analysis

Hierarchical and non-hierarchical clustering methods. Classification and discrimination procedures for discrimination between two known populations – Bayes, Minimax and Likelihood Ratio procedures. Discrimination between two multivariate normal populations. Sample discriminant function. Likelihood ratio rule. Tests associated with discriminant function, Probabilities of misclassification and their estimation. Classification of several populations. Fisher's method for discriminating among several populations. Population and sample principal components and their uses and related large sample inference. The orthogonal factor model, Estimation of factor loading, Factor rotation, Estimation of Factor scores, Interpretation of Factor Analysis.
[25]

References

R. A. Johnson & D. W. Wichern. : Applied Multivariate Statistical Analysis

N. H. Timm. : Applied Multivariate Analysis

A. V. Rencher & W. F. Christensen. : Methods of Multivariate Analysis

W. K. Hardle & L. Simar. : Applied Multivariate Statistical Analysis

W. K. Hardle & Z. Hlavka. : Multivariate Statistics: Exercises and Solutions

T. W. Anderson.: An Introduction to Multivariate Statistical Analysis
G. A. F. Seber.: Multivariate Observations
B. Everitt & T. Hothorn. : An Introduction Applied Multivariate Analysis with R

STA 535: Project Work

Theory and / or application of statistical methods.

STA 536: Practical IV

Practical exercises related to topics in STA 531-534.

Advanced Papers

Module I : Survival Analysis, & Bayesian Inference & Applications

Survival Analysis

Concepts of lifetime, Various schemes of censoring and associated likelihoods. Estimation of survival function: Parametric procedure: Point estimation, Scores and likelihood ratio tests for selected parametric models and confidence intervals. Distribution free procedures: Actuarial estimator, Kaplan-Meier and Nelson – Aalen estimators. Regression models: Estimation in parametric and Semi-parametric models-Cox's proportional hazard model, Time dependent covariates, Rank test. Competing risk analysis and Multivariate models.

[25]

References

D. J. Kleinbaum & M. Klein. : Survival Analysais : A Self-Learning Text
D. W. Hosmer, S. Lemeshow, & S. May. : Applied Survival Analysis: Regression Modeling of Time to Event Data
J. P. Klein & M. L. Moeschberger. : Survival Analysis : Techniques for Censored and Truncated Data
D. R. Cox & D. Oakes. : Analysis of Survival Data
J. D. Kalbfleisch & R. L. Prentiice. : The Statistical Analysis of Failure Time Data
R. G. Miller. : Survival Analysis
P. J. Smith. : Analysis of Failure and Survival Data
A. J. Gross & A. V. Clark. : Survival Distribution: Reliability Applications in the Biomedical Sciences
D. F. Moore. : Applied Survival Analysis Using R

Bayesian Methods II

Bayesian linear Model and Regression. Hierarchical and Empirical Bayes estimation. parametric empirical Bayes estimator and its computation. Bayesian computation and simulation: Markov Chain Monte Carlo (MCMC), Gibbs Sampling, Metropolis Hastings (MH) algorithm. Testing and Model selection.

References

P. M. Lee. : Bayesian statistics: An Introduction.
P. D. Hoff. : A First Course in Bayesian Statistical Methods
J.K. Ghosh, M. Delampady, & T. Samanta. : An Introduction to Bayesian Analysis: Theory and Methods
A. Gelman et al. : Bayesian Data Analysis
B. P. Carlin, & T. A. Louis. : Bayesian Methods for Data Analysis
C.P. Robert. : The Bayesian Choice
J.-M. Marin, & C.P. Robert. : Bayesian Core: A Practical Approach To Computational Bayesian Statistics
J.-M. Marin, & C.P. Robert. : Bayesian Essentials with R
J. Albrt. : Bayesian Computation with R

Module II: Advanced Survey Sampling

Advanced Sample Survey

The basic model, Sampling Design and sampling schemes. Hanurav's unit drawing algorithm: Inclusion probabilities of first two orders, Relation with effective sample size and variance of effective sample size. Data and estimators-linear and linear unbiased estimators of population total, Horvitz –Thompson estimator, Generalized difference and generalized regression estimators, issues in non-negative variance estimation. π-PS sampling schemes of Midzuno-Sen, Brewer, Durbin and JNK Rao, Rao-Hartley-Cochran strategy. Randomised response: The Warner model: unbiased and maximum likelihood estimation. The unrelated question models methods (one and two unrelated characters)-unbiased estimation under the cases where the population in the unrelated group is known/unknown, comparison with the Warner model. Small Area Estimation - the basic estimation method, ratio and regression estimators for domains. Issues in small domain estimation - synthetic estimators. Adaptive sampling for rare and elusive population.

References

C. M. Cassel, E. Sarndal, & J. H. Wretman. : Foundations of Inference in survey Sampling.
A. Chaudhuri & H. Stenger. : Survey **S**ampling—Theory and Methods
A. Chaudhuri. : Essentials of Survey Sampling
A. Chaudhuri & J. W. E. Vos. : United Theory and Strategies of Survey Sampling
A. S. Hedayat & B. K. Sinha. : Design and Inference in Finite Population Sampling
P. Mukhopadhyay. : Inferential Problems in Survey Sampling
C. E. Sarndal, B. Swensson & J. Wretman. : Model assisted Survey Sampling
S. Thompson & G. Seber. : Adaptive Sampling

Model-dependent Inference in Survey Sampling

Inference under fixed population model: sufficiency and likelihood. Choosing good sampling strategy. Nonexistence theorem of Godambe and Joshi. Inference under super population model. Prediction approach. Asymptotic approach- asymptotic design unbiasedness and consistency. Finite population distribution function estimation : Chambers-Dunstan and Rao-Kovar-Mantel estimator. Resampling methods in finite population inferences (Only introduction). Bayesian Estimation in survey sampling – Empirical Bayes & Hierarchical Bayes estimators. Model based inference in small area estimation – Fay - Herriot model. [25]

References

C. M. Cassel, E. Sarndal, & J. H. Wretman. : Foundations of Inference in survey Sampling.
A. Chaudhuri & H. Stenger. : Survey **S**ampling—Theory and Methods
A. Chaudhuri. : Essentials of Survey Sampling
A. S. Hedayat & B. K. Sinha. : Design and Inference in Finite Population Sampling
E. Sarndal., B. Swensson & J. Wretman. : Model Assisted **S**urvey Sampling
W. Fuller. : Sampling Statistics
J. N. K. Rao. : Small Area Eatimation
P. Mukhopadhyay. : Topics in Survey Sampling
R. Chambers & R. Clark. : An Introduction to Model-Based Survey Sampling with Applicationns
R. L. Chambers & C. J. Skinner. : Analysis of Survey Data
R. L. Chambers et al. : Maximum Likelihood Estimation for Sample Survey
Z. Mashreghi et al. : A Survey of Bootstrap Method in Finite Population Sampling
J. Shao & D. Tu. : The Jackknife and Bootstrap

Module II: Industrial Statistics

Operations Research

Definition and Scope of Operations Research: phases in Operation Research, models and their solutions, decision-making under uncertainty and risk, use of different criteria, sensitivity analysis. 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 mixed strategy games. Analytical structure of inventory problems, EOQ formula of Harris, its sensitivity analysis and extensions allowing quantity discounts and shortages. Multi-item inventory subject to constraints. Models with random demand, the static risk model. P- and Q- systems with constant and random lead times. Queuing models – specification and effectiveness measures. Steady-state solutions of M/M/1 and M/M/c models with associated distributions of queuelength and waiting time. M/G/1 queue and Pollazcek-Khinchine result. Network Flow Models, minimum spanning tree, shortest path, mincut-maxflow, CPM and PERT using network flow. Traveling salesman Problem. Replacement theory, sequencing. [25]

References

H. A. Taha. : Operational Research
F. S. Hillier & G. J. Leiberman. : Introduction to Operations Research
Kanti Swarup, P. K. Gupta & M. M. Singh. : Operations Research
D. T. Philips, A. Ravindran & J. Solberg. : Operations Research
C. W. Churchman, R. L. Ackoff & E. L .Arnoff. : Introduction to Operations Research
T. M. Starr & D. W. Miller. : Inventory Control - Theory & Practice
L. Kleinrock. : Queueing Systems
M. Sasieni, A. Yaspan & L. Friedman. : Operations Research
R. L. Ackoff. & M. W. Sasieni : Fundamentals of Operation Research.

Optimization

Generalized L.P.P. Bounded variables, decomposition principle of Dantizg and Wolfe. Transportation problem. Unconstrained Optimization, Optimality Conditions, first-order, second-order necessary sufficiency under convexity. Algorithms for Univariate Optimization: Bisection, Newton, Safeguarded Newton, Golden section search, Fibonacci rates of convergence. Integer programming – integer linear and mixed integer linear programming problems, Gomery's cutting plane method, Branch and Bound method. Binary Programming – Bala's algorithm ISI. Non-linear programming –optimization with equality & inequality constraints: Details of Karush-Kuhn-Tucker theory, Quadratic Programming – Wolfe's algorithm and Beale's algorithm. [25]

References

G. Hadley. : Non-linear and Dynamic Programming
K. G. Murthy. : Linear and Combinatorial Programming
P. Whittle. Optimization under Constraints - Theory and Applications of Non-linear Programming
S. S. Vajda. : Probabilistic Programming
N. S. Kambo. : Mathematical Programming Techniques

S. S. Rao. : Optimization - Theory and Applications
K. V. Mittal. : Optimization Methods

Module III: Econometrics and Financial statistics

Econometric Methods

Single-equation linear model – some variations. Nonparametric methods in econometrics. Simultaneous Equations – identification & estimation. Analysis of Panel Data. Bayesian Econometrics. Demand Analysis. Production Function Analysis. Analysis of some special econometric models. [25]

References

J. Johnston. : Econometric Methods
G. G. Judge, et.al. : The Theory and Practice of Econometrics
W. Greene. : Econometric Analysis
A. Zellner. : An Introduction to Bayesian Inference in Econometrics
E. Malinvaud. : Statistical Methods in Econometrics
H. Wold & L. Jureen. : Demand Analysis – a study in econometrics
P. Sankhayan. : An Intro.to the Economics of Agricultural Production
M. Nerlove. : Estimation and Identification of Cobb-Douglas Models
A. Pagan & A. Ullah. : Nonparametric Econometrics

Statistics in Finance

The value of time, Bond Pricing with a flat term structure, The term structure of interest rates and an object lesson,The Mean Variance Frontier, The global minimum variance portfolio, Efficient portfolio, The zero beta portfolio,Allowing for a riskless asset, Efficient sets with risk free assets, Pricing of futures contract, Binomial option pricing, Multiperiod binomial pricing, Basic Option Pricing, the Black Scholes formula, Extending the Black Scholes formula, Dividends. Risk-free and risky assets. Contracts and options. Continuously compounded interest, present valuation, risk, risk-neutral valuation. Arbitrage: examples, contracts and options under no-arbitrage assumptions.
Option Pricing: Cox-Ross-Rubinstein Binomial and Black-Scholes models.
Elementary portfolio management, Value-at-risk. [25]

References

D. Ruppert. : Statistics and Finance
D. Reppert. : Statistics and Data Analysis for Financial Engendering
E. Lindstrom, H. Madsen & J. N. Nielsen. : Statistics for Finance
J. Franke, W. K. Hardle, & C. M. Hafner. : Statistics for Financial Markets

S. M. Ross.：Introduction to Mathematical Finance: Options and Other Topics
N. H. Bingham & R. Kiesel. : Risk-Neutral Val. : Pricing & Hedging of Financial Derivatives
V. S. Bawa, S. J. Brown, & R. W. Klein. : Estimation Risk and Optimal Portfolio Choice.
R. Carmona. : Statistical Analysis of Financial Data Using R.