UNIVERSITY OF CALCUTTA

NotificationNo.CSR/02/23

It is notified for information of all concerned that the Syndicate in its meeting dated 02.09.2022 (vide Item No.1 placed on Table) approved & subsequently confirmed by the Syndicate dated 24.11.2022(Item No.01) the approval of the new PG Syllabus in Statistics, under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the session 2022 -2023.

08/6/2023

Prof.(Dr.) Debasis Das

Registrar

REGISTRAR
UNIVERSITY OF CALCUTTA

SENATE HOUSE

KOLKATA-700 073

08/06/2023

UNIVERSITY OF CALCUTTA

Revised Syllabus & Admission Rules for Two-year Post Graduate(M.Sc.) Course
&
Regulations for the M.Sc. Examinations
in
STATISTICS

2022

A student will be eligible for admission to the course if he/she is an Honours graduate in Statistics from Calcutta University or has passed the B.Sc. (Honours) in Statistics /B.Stat examination securing the requisite marks in the aggregate from any other University/Institution.

In general, the regulations for the two year (four semester) M.Sc. degree course in Statistics applicable from the academic year 2022-23 will be same as the comprehensive and uniform regulations of Calcutta University (Notification CSR/62/17).

Some particular points in the regulations for the Examinations in each of the semesters are as follows:

1. Each semester will have 5 courses as detailed below. All courses are of 4 Credits, comprising of either a Theoretical component only (carrying 50 marks) or a Practical component only (carrying 50 marks) or both (carrying 40 marks for Theoretical & 10 marks for Practical).
2. The end-semester examinations for the theoretical papers will be held after the completion of the classes of that semester. Twenty five percent of the marks in the theoretical component of each paper will be awarded based on internal assessment, which will include a mid–semester test and/or any other form of assessment as decided by the concerned teacher. The Practical components will be marked based on continuous assessment as well as a final Viva-Voce examination.

3. Twenty five percent credit points are allotted to each semester. One theory credit point is equivalent to one hour of class per week while one practical credit point is equivalent to one and a half hours of class per week.
4. The examinations for theoretical components (excluding internal assessment marks) with ≤ 25 marks and 26-50 marks will be of 1 hour and 2 hours duration, respectively (Notification CSR/89/18; https://www.caluniv.ac.in/cbcs-pg/pg-files/CSR-5-10-18.pdf).

5. A candidate shall be eligible for appearing at any of the Semesters of P.G. Examination provided he/she possesses the stipulated percentage of attendance (Notification CSR/89/18; https://www.caluniv.ac.in/cbcs-pg/pg-files/CSR-5-10-18.pdf).

6. Students need to appear at the examination of each and every paper in each course. In order to be declared pass, the student must obtain at least 40% marks in each course. In case of courses containing both theoretical and practical parts, students must secure at least 35% of marks in theoretical papers and at least 35% of marks in practical papers separately and at least 40% marks in the aggregate to be deemed passed in that course.
7. Students failing to obtain pass marks in at least one of the courses in either of the semesters can sit for a supplementary examination as per the regulations of Calcutta University (Notification CSR/89/18; https://www.caluniv.ac.in/cbcs-pg/pg-files/CSR-5-10-18.pdf& CSR 104/18; https://www.caluniv.ac.in/cbcs-pg/pg-files/CSR104-16-11-18.pdf).
8. Students will be required to select 1 elective paper in the 3rd semester and 2 elective papers in the 4th semester. These are detailed in the syllabus of the respective semester.
9. Students will need to start their major project work in the 3rd semester and continue the same in the 4th semester. They will be required to submit a written report and also make formal presentation(s) at the end of the 4th semester.

Syllabus for Post-Graduate(M.Sc.) Course in Statistics

(Marks in the right-hand column are shown as Theoretical(TH) marks + Practical(PR) marks)

Semester I : Total credits = 20 (Total Marks = 250)

Course No.	SUBJECT	CREDIT POINTS	MARKS (TH+PR)
STAT 101 :	Analysis I	4	50 + 0
STAT 102 :	Probability I	4	50 + 0
STAT 103 :	Statistical Inference I	4	40 + 10
STAT 104 :	Linear Models & Regression Analysis I	4	40 + 10
STAT 105 :	R Programming	4	0 + 50

Semester II : Total credits = 20 (Total Marks = 250)

Course No.	SUBJECT	CREDIT POINTS	MARKS (TH+PR)
STAT 201 :	Probability II	4	50 + 0
STAT 202 :	Multivariate Analysis	4	40 + 10
STAT 203 :	Statistical Inference II	4	40 + 10
STAT 204 :	Regression Analysis II	4	40 + 10
STAT 205 :	Design of Experiments & Sample Surveys	4	40 + 10

Semester III : Total credits = 20 (Total Marks = 250)

In this semester, students will be required to select one elective paper in Statistics from the list below. However, all papers in the list may not be offered in a particular year and it will be at the discretion of the Department to decide which papers to offer in the particular year.

There will be two Choice-based courses that the students will have to take from other Departments. The courses offered and the selection process for these two papers will be as per the general decisions of the University.

Course No.	SUBJECT	CREDIT POINTS	MARKS(TH+PR)
STAT 301 :	Statistical Inference III	4	40 + 10
STAT 302 :	Applied Multivariate Analysis	4	40 + 10
STAT 303-307 :	Elective 1	4	50 (or 40+10)
	Choice-based Course 1	4	50
	Choice-based Course 2	4	50

Choice of Elective papers:

Elective 1 : *Any one from the following*

STAT 303 : Analysis II

STAT 304 : Applied Bayesian Methods & Semiparametric Methods

STAT 305 : Operations Research

STAT 306 : Biostatistics I

STAT 307 : Astrophysics and related data sources

Semester IV : Total credits = 20 (Total Marks = 250)

In this semester, students will be required to select one elective paper from each of two groups as listed below. Each of the groups contains 5 papers. However, all of these may not be offered in a particular year and it will be at the discretion of the Department to decide which papers to offer in the particular year.

Course No.	SUBJECT	CREDIT POINTS	MARKS (TH+PR)
STAT 401 :	Stochastic Processes & Time Series Analysis	4	40+10
STAT 402 :	Advanced Data Analytic Techniques	4	40+10

STAT 403-407 :	Elective 2	4	40 + 10 or 50 + 0
STAT 408-413 :	Elective 3	4	40 + 10 or 50 + 0
STAT414 :	Project Work	4	0 + 50

Choice of Elective Papers :

Elective 2 : ***Any one from the following***

STAT 403 : Probability III

STAT 404 : Applied Stochastic Models

STAT 405 : Advanced Parametric Inference

STAT 406 : Biostatistics II

STAT 407 : Statistical Analysis of Big Data

Elective 3 : ***Any one from the following***

STAT 408: Advanced Probability (***Prerequisite: STAT 303 : Analysis II***)

STAT 409 : Advanced Nonparametric Inference

STAT 410 : Reliability Theory

STAT 411 : Directional and Spatial Statistics

STAT 412 : Statistical Genetics

STAT 413 : Econometrics

Detailed Syllabus

Semester I

STAT 101 : Analysis I (4)

Real Number System: Axioms, Bounded and unbounded subsets of the line ,supremum, infimum, intervals, Countable and Uncountable Set, Archimedean property of R, Density property of R, Extended real line. (10)

Sequence: subsequence, convergence, divergence, bounded sequences, limits superior and inferior, monotone sequences, Cauchy sequences, completeness, Bolzano-Weierstrass Theorem. (7)

Series of real numbers: Different tests of convergence, Absolute convergence, conditional convergence, Rearrangement of series (3)

Topological properties: closed and open sets, characterizations, limit points, closures, interiors. Denseness. Bolzano-Weierstrass Theorem, Compact sets, Cantor Intersection Theorem, Heine-Borel Theorem (statement only) (7)

Limits, continuity, uniform continuity, intermediate value theorem, differentiability; mean value theorem, Taylor's theorem (statement), extrema. (12)

Riemann integral: Upper and lower integral, Fundamental theorem of calculus, Integration by parts (6)

Sequences and series of functions: uniform convergence, power series, term-by-term differentiation and integration. (5)

References :

T.M.Apostol	:	Mathematical Analysis
W.Rudin	:	Principles of Mathematical Analysis
D. R. Sherbert & R.G. Bartle	:	Introduction to Real Analysis, 4ed
S. R. Ghorpade& B.V. Limaye	:	A Course in Calculus and Real Analysis
S. R. Ghorpade&B.V. Limaye	:	A Course in Multivariable Calculus and Analysis
R.R.Goldberg	:	Methods of Real Analysis

STAT 102 :Probability I (4)

Fields, sigma-fields and generators, semifields, Borel sigma-field on R. Monotone classes, monotone class theorem, pi-lambda theorem. (8)

Finitely additive measures, measures, continuity properties; finite, sigma-finite measures. Probability measures, properties. Independence of events, Borel-Cantelli lemmas. (5)

Extensions of measures, Caratheodory's theorem (statement). Lebesgue measure on R: construction, properties. (3)

Measurable functions and properties, Generated sigma-fields. Induced measures. Compositions. Examples. Random variables, probability distributions, distribution functions, examples. Product measurable spaces; characterizations; random vectors, multivariate distributions, examples. (8)

Convergence in measure, almost everywhere and their connections. (2)

Integration: simple, nonnegative, general measurable functions, integrability. Expectations, moments. Monotone Convergence Theorem, Dominated Convergence Theorem, Fatou's lemma. Connection with Riemann Integration. Change of variables. (14)

Holder's, Cauchy-Scwartz and Jensen's inequalities. Moments of random variables. (2)

Absolute continuity and singularity of measures. Radon-Nikodym Theorem (Statement). Discrete and absolutely continuous distributions. Lebesgue's differentiation theorem (statement), probability densities. (3)

Product measures. Fubini's theorem. Lebesgue measure on Rk. Independent random variables. Asymptotics of independent random variables: tail sigma-field, Kolmogorov's 0-1 law. (5)

References :

S. Resnick	:	A Probability Path
M. Capinski & T. Zastawniak	:	Probability Through Problems
P. Billingsley	:	Probability and Measure
R. Ash & C. Doleans-Dade	:	Probability and Measure Theory
A. K. Basu	:	Measure Theory and Probability

STAT 103 : Statistical Inference I (4)

Point Estimation (12)

Sufficiency and completeness, Exponential and Extended Exponential families. (6)

Rao-Blackwell and Lehmann-Scheffe Theorems, Minimum Variance Unbiased Estimators. (6)

Testing of Hypotheses I (28)

Review of notions of nonrandomized and randomized tests, level, size, p-value, power function, Fundamental Neyman-Pearson lemma, UMP Tests. (10)

Monotone Likelihood Ratio. (4)

Generalized Neyman-Pearson Lemma. (1)

UMPU Tests for Simple and Composite hypotheses (11)

Confidence sets, relation with hypothesis testing, UMA and UMAU confidence intervals. (2)

***References* :**

E.L.Lehman : Testing Statistical Hypotheses

S.Zacks : The Theory of Statistical Inference

C.R.Rao : Linear Statistical Inference and its Applications

E.L.Lehmann : Theory of Point Estimation

T.S.Ferguson : Mathematical Statistics

STAT 104 : Linear Models & Regression Analysis I (4)

Linear Models (20)

Gauss Markov Model: Estimable function, error function, BLUE, Gauss Markov theorem. Correlated set-up, least squares estimate with restriction on parameters. (7)

Linear Set, General linear hypothesis – related sampling distribution, Multiple comparison techniques due to Scheffe and Tukey. (7)

Analysis of variance: Balanced classification, Fixed Effects Model, Random Effects Model and Mixed Effects Model; Inference on Variance components. (4)

Analysis of covariance. (2)

Regression Analysis I (20)

Building a regression model: Transformations – Box-Cox and Box-Tidwell models. (2)

Stepwise regression. (2)

Model selection (adjusted R2, Cp criteria, AIC). (4)

Multicollinearity – detection and remedial measures. (4)

Dummy variables, piecewise regression, splines and scatter plot smoothing. (4)

Detection of outliers and influential observations: residuals and leverages, DFBETA, DFFIT, Cook's Distance. (4)

References :

C.R. Rao	:	Linear Statistical Inference and its Applications
R. B. Bapat	:	Linear Algebra and Linear Model :
H.Scheffe	:	The Analysis of Variance
S.R.Searle	:	Linear Models
G.A.F.Seber	:	Linear Regression Analysis
N.C. Giri	:	Analysis of Variance
N.R.Draper&H.Smith	:	Applied Regression Analysis
D.W.Belsley, E.Kuh &R.E.Welsch:		Regression Diagnostics – identifying Influential data & sources of collinearity
J.Rousseeuw & A.M.Leroy	:	Robust Regression & Outlier Detection
R.D.Cook&S.Weisberg	:	Residual and its Influence in Regression
S. Chatterjee & A.S. Hadi	:	Regression Analysis by Example

STAT 105 : R Programming (4)

Data types in R.

R Graphics.

Basic statistics using R.

Vector matrix operations : Simple matrix operations; Linear equations and eigenvalues, Matrix decomposition – LU, QR and SVD; Matrix inverse and G inverse; Finding a basis, orthonormalization, finding rank.

Linear models: the lm function; ANOVA/ANCOVA/regression, models, the summary function, goodness of fit measures, predicted values and residuals; the ANOVA table,

confidence intervals and confidence ellipsoids; Multiple testing.

Random number generation & Simulations.

Programming in R: Numerical Methods

References :

P.Dalgaard	:	Introductory Statistics with R, Springer, 2nd ed,2008.
J.Maindonald&J.Braun	:	Data Analysis and Graphics Using R , Cambridge University Press, Cambridge, 2nd edition, 2007.
J.J.Faraway	:	Linear Models with R ,Chapman& Hall/CRC Texts in Statistical Science.

Semester II

STAT 201 : Probability II (4)

Minkowski's inequality. Lp spaces, Lp-convergence of random variables, connections with other modes of convergence. (4)

Convergence in distribution. Examples. Connections with other modes of convergence. Helly-Bray, Portmanteau theorems (statement and applications). Scheffe's theorem, Slutsky's theorem. (6)

Integration of complex-valued functions, characteristic functions. Convolutions. Inversion and Continuity theorems. (5)

Weak and strong laws of large numbers. (6)

Central Limit Theorems. (4)

Stochastic Processes: Introduction, classifications of stochastic processes, counting processes. (1)

Discrete-time Markov chains: time-homogeneity, one-step & multi-step transition probabilities, Chapman-Kolmogorov equations, Markov times, strong Markov property, classification of states, stationary distributions, periodicity, ergodicity, convergence, reversibility, elementary MCMC methods. Examples: birth-and-death processes, branching processes (18)

Poisson process: postulates, properties; compound PP, non-homogeneous PP. (6)

References :

S. Resnick	:	A Probability Path
P. Billingsley	:	Probability and Measure
R.Ash & C. Doleans-Dade	:	Probability and Measure Theory
K. B. Athreya & S. N. Lahiri	:	Measure Theory and Probability Theory
A. K. Basu	:	Measure Theory and Probability

STAT 202 : Multivariate Analysis (4)

Basics of topology of Euclidean spaces: Euclidean distance, convergent and Cauchy sequences, completeness, limit points of sets, Bolzano-Weierstarss theorems (both forms), open, closed sets, closure and interior; compact sets, Heine-Borel theorem. (2)

Functions of several variables: continuity, sequential criterion, uniform continuity, equivalence on compact domains. (1)

Derivatives: directional, partial derivatives, total differentiability, connections with continuity and directional derivatives, conditions for total differentiability, mean value theorem, higher order derivatives, equality of mixed partial derivatives, Taylor's theorems. (4)

Copulas: definition, examples, Sklar's theorem, copula density, classes of copula and their properties, empirical copulas, applications (5)

Multivariate statistics: multivariate distributions: marginals, moments, simple and multiple correlation and linear regression, conditional distributions and moments, partial correlation; characteristic function and uniqueness theorem. (1)

Elliptical distribution: Definition, examples, properties, applications; spherical distribution; multivariate t-distribution. (5)

Multivariate normal distribution: definition, marginals, characterizations, characteristic function, joint distributions of affine forms, singular case, joint, marginal and conditional densities in the nonsingular case. (3)

Univariate sampling distributions based on normal: non-central χ^2, t & F distributions – definitions and selected properties. X^2 distribution of quadratic forms, Fisher-Cochran theorem, applications; independence of quadratic and affine forms. (6)

Sampling from multivariate normal distribution, MLEs, distributions and independence of sample mean vector and variance-covariance matrix. Wishart distribution. Properties of Wishart distribution. Distribution of conditional dispersion matrix. (4)

Null distributions of simple, multiple and partial correlation coefficients and regression coefficients, associated tests. (3)

Hotelling T^2: definition, distribution and applications in testing in single and two-sample cases and confidence set construction. (3)

Mahalanobis's D^2: definition and role in classification in brief. (1)

Canonical correlation: Definition; Conceptual overview; canonical weights and scores. Usefulness. (2)

References :

C.R.Rao : Linear Statistical Inference and its Applications

T.W.Anderson : Introduction to Multivariate Analysis

A.M.Khirsagar : Multivariate Analysis

S.S.Wilks : Mathematical Statistics

G A F Seber: Multivariate Observations

M.S.Srivastava & C.G.Khatri : Introduction to Multivariate Statistics

R.J.Muirhead : Aspects of Multivariate statistical Theory

S. R. Ghorpade & B.V. Limaye : A Course in Calculus and Real Analysis

STAT 203 : Statistical Inference II (4)

Bayesian Analysis (**14**)

Elements of decision theory - Preliminary ideas of decision rules, loss and risk.

Overview and comparison of two paradigms – Classical statistical analysis and Bayesian analysis. Relative advantages and disadvantages, Motivation for choice of different priors. (5)

Bayesian Inference – estimation, testing, interval estimation and prediction for some common models and common priors, Hierarchical Bayes, Brief discussions on Bayesian computational techniques and their applications. (9)

Sequential Analysis (**10**)

Stopping variables, Sequential Tests, Wald's equation for ASN, SPRT and its properties – fundamental identity, OC and ASN, Optimality of SPRT (under usual approximation).(10)

Asymptotic Inference (16)

Consistency and Asymptotic Efficiency of Estimators, Maximum Likelihood estimators and their Large sample properties. (10)

Asymptotic distributions and properties of Likelihood ratio tests, Rao's score test and Wald's tests in the simple hypothesis case. (6)

References:

R.J. Serfling : Approximation Theorems of Mathematical Statistics

E.L. Lehmann : Large Sample Theory

C.R. Rao : Statistical Inference and its Applications

J.O. Berger : Statistical Decision Theory and Bayesian Analysis

J.K. Ghosh, M. Delampady & T. Samanta : Bayesian Inference

P. Lee : Bayesian Statistics ‑An Introduction

B.K.Ghosh : Sequential Tests of Statistical Hypotheses

A. Wald : Sequential Analysis

N. Mukhopadhyay& B. M. de Silva: Sequential methods and their applications.

STAT 204 : Regression Analysis II (4)

Departures from the Gauss-Markov set-up

Heteroscedasticity and Autocorrelation – consequences, detection and remedies.(8)

Checking for normality: Q-Q plots, Normal Probability plot, Shapiro-Wilks test. (2)

Analysis of Categorical Data

Measures of association for classified nominal and ordinal categorical data. (8)

Generalized Linear Models: Introduction, Components of a GLM, Maximum Likelihood estimation, Deviance. (6)

Binary data and Count data: ungrouped and grouped. Models with constant coefficient of variation. Polytomous data. (8)

Overdispersion and fitting by quasi-likelihood. (2)

Extensions of GLMs: Zero inflated Poisson models, Joint modeling of mean and variance, Concept of Generalized Linear Mixed Models (GLLM). (6)

References :

J.Johnston : Econometric Methods (3rd ed.)

G.G.Judge, W.E.Griffith, et. al. : The Theory and Practiceof Econometrics (2nd ed.)
T.P. Ryan : Modern Regression Methods (2nd ed.)
S. Chatterjee & A.S. Hadi : Regression Analysis by Example
A. Agresti : Analysis of Ordinal Categorical Data
A. Agresti : Categorical Data Analysis
P.McCullagh&A.J.Nelder : Generalized Linear Models
C.E.McCullough&S.R.Searle : Generalized, Linear and Mixed Models, 2nd ed.
T.Hastie&R.Tibshirani : Generalized Additive Models

STAT 205 : Design of Experiments and Sample Surveys (4)

Design of Experiments (25)

Block Designs: Review of Linear Model methods and general analysis of block designs for one way heterogeneity set up; notions of connectedness, orthogonality, and balance. (8)

Mutually orthogonal Latin squares (MOLS) of order v, construction of a complete set of MOLS when v is a prime/prime power. (4)

Balanced Incomplete Block Designs: Definition, application, properties, analysis, constructions, Resolvability: Bose's Inequality. (8)

Row-Column Designs: Applications and general analysis, introduction to Youden square designs. (2)

Optimality of Block Designs: Choosing an appropriate design for an experiment: A,D, E and Universal optimality; Optimality of BIBD. (3)

Sample Surveys (15)

Probability sampling from a finite population – Notions of sampling design, sampling scheme, inclusion probabilities, Estimation of sample size. Concepts of estimability & optimality. Horvitz-Thompson estimator of a population total. (4)

Basic sampling schemes – Simple random sampling with and without replacement, Unequal probability sampling with and without replacement, Systematic sampling. Related estimators of population total/mean, their variances and variance estimators – Mean per distinct unit in simple random with replacement sampling, Hansen-Hurwitz estimator in unequal probability sampling with replacement, Des Raj and Murthy's estimator (for sample

size two) in unequal probability sampling without replacement and applications to stratified sampling. (10)

Basic idea of Small Area Estimation (1)

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

D.Raghavarao & L.V.Padgett: Block Design: Analysis, Combinatorics and Applications

R.C.Bose : Mathematical Theory of Symmetric Factorial Design (Sankhya – Vol. 8)

D. G. Kabe and A. K. Gupta: Experimental Designs: Exercises and Solutions

G. Casella : Statistical Design

T. P. Ryan : Modern Experimental Design

C. F. J. Wu &M. S. Hamada: Experiments: Planning, Analysis and Optimization (2^{nd} edition)

D.C.Montogomery : Design and Analysis of Experiments

W.G. Cochran : Sampling Techniques, 3rded.

Des Raj & Chandak : Sampling Theory

A.S. Hedayat & B.K. Sinha : Design and inference in finite population sampling

P. Mukhopadhyay : Theory & Methods of Survey Sampling

M.N. Murthy : Sampling Theory and Methods

J.N.K. Rao and Isabel Molina: Small area estimation, Second edition.

Semester III

STAT 301 :Statistical Inference III (4)

Decision Theory (**20**)

Decision Problem and two-person game, Nonrandomized and randomized rules, Risk function, Admissibility of decision rules, Complete, essentially complete, minimal complete and minimal essentially complete classes. Essential completeness and completeness of

class of rules based on sufficient statistic and the class of nonrandomized rules for convex loss. (7)

Bayes rules, Extended Bayes, Generalized Bayes and Limit of Bayes rules, Admissibility of Bayes rule. (7)

Minimax rules, Method for finding minimax rules. (6)

Nonparametric Methods (**20**)

Elementary concepts and properties of U-statistics and Linear Rank Statistics, Single sample location, location cum symmetry and goodness-of-fit problems. (8)

Two-sample location, scale and homogeneity problems, Multi-sample location problem: One way & Two way data, Bivariate association problem. (8)

Related nonparametric interval estimation; Concept of asymptotic relative efficiency. (4)

References :

C.R.Rao	:	Linear Statistical Inference and its Applications
E.L.Lehmann	:	Theory of Point Estimation
T.S.Ferguson	:	Mathematical Statistics
D.A.S.Fraser	:	Nonparametric methods in Statistics
J.D. Gibbons	:	Nonparametric Inference
T.P.Hettmansperger	:	Statistical Inference based on ranks
J.O.Berger	:	Statistical Decision Theory and Bayesian Analysis

STAT 302 : Applied Multivariate Analysis (4)

Distance measures for continuous, discrete and mixed data. (2)

Clustering: Hierarchical clustering – Agglomerative and Divisive algorithms, Partitioning – k-means or medoids clustering optimum choice of the number of clusters. (6)

Classification and discrimination procedures: Discrimination between two known populations – Bayes, Minimax and Likelihood Ratio procedures. LDA, QDA, Logistic classifiers Probabilities of misclassification and their estimation. Fisher's method and multinomial classifiers for several populations. (8)

Principal Component Analysis: Population and sample Principal components and their uses. Plotting techniques, Independent Component Analysis. (6)

Factor Analysis: The orthogonal factor model, Estimation of factor loading, Factor rotation, Estimation of Factor scores, Interpretation of Factor Analysis. (8)

Correspondence Analysis (2)

Multivariate linear model: estimation of parameters, tests of linear hypotheses, Multivariate Analysis of variance of one and two way classified data, simultaneous confidence intervals, Multivariate Analysis of Covariance. (8)

References :

T.W.Anderson : An Introduction to Multivariate Statistical Analysis, (2_{nd}ed.)

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

D.F.Morrison : Multivariate Statistical Methods

G.A.F.Seber : Multivariate Observations

S.C.Sharma : Applied Multivariate Techniques

Elective Papers

Elective - 1

STAT 303 :Analysis II (4)

Infinite-dimensional vector spaces & subspaces. characterizations, examples - sequence spaces, general function spaces, Lebesgue spaces. Normed linear spaces, Seminorms and quotient spaces. (6)

Metric spaces : open, closed, closures, interiors, dense sets, sequences and limits, subsequences, completeness, compactness, separability and consequences. Functions and continuity, uniform continuity, connectedness. (12)

Brief discussion of Banach spaces. (5)

Inner product spaces, orhtogonality, closed subspaces and projections. orthocomplements. Hilbert spaces, orthonormal basis, applications to Statistics. Brief introduction to Fourier Analysis. (7)

Complex Analysis : Algebra of complex numbers, the complex plane, polynomials, power series. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem,

Cauchy's integral formula, Liouville's theorem, Taylor series, Laurent series, calculus of residues. Some special characteristic functions. (20)

References :

T.M.Apostol	:	Mathematical Analysis
W.Rudin	:	Principles of Mathematical Analysis
R.R.Goldberg	:	Methods of Real Analysis
K.M. Hoffman & R.Kunze	:	Linear Algebra (2nd Edition)
J.B.Conway	:	Functions of one complex variable
R.Courant & F. John	:	Introduction to Calculus and Analysis- Vol. II
W.Brown &R.V.Churchill	:	Complex Variables and Applications (8^{th}ed.)
G.F. Simmons	:	Introduction to Topology and Modern Analysis

STAT 304 : Applied Bayesian Methods & Semiparametric Methods (4)

Semiparametric Methods (20)

Difference between Parametric, Nonparametric and Semiparametric Methods, Different types of likelihood functions. (10)

Single-Index Models. Generalised Partial Linear Models. Generalized Additive Models. Categorical data and related tests of significance. (10)

Applied Bayesian Methods (20)

Bayesian Linear Regression with Conjugate priors, Bayesian Model Selection, Bayesian Information Criterion. Monte Carlo Method, Markov chains and MCMC, Gibbs Sampling with examples in R and WinBUGS, The Metropolis-Hastings Algorithm. (8)

Generalized linear models and categorical data, longitudinal models, Bayesian multiple imputation. Bayesian Hypothesis Testing (One-sided and Two-sided Example), The Bayes Factor, A Test for Comparing Two Population Means. Hierarchical Bayes Examples, Exchangeability, Hierarchical Bayesian Analysis. (8)

Bayesian Probit and Logistic Regression (Multi-category Ordinal Response). Multinomial-Dirichlet model. Nonparametric Bayes. (4)

References :

J.O. Berger	:	Statistical Decision Theory and Bayesian Analysis

C.P.Robert : The Bayesian Choice
J.K.Ghosh, M.Delampady&T.Samanta: Bayesian Inference
P.Lee : Bayesian Statistics – An Introduction
Härdle, Müller, Sperlich & Werwatz: Non- and SemiparametricModelling
D.Ruppert, M.P. Wand and R.J. Carroll: Semiparametric Regression
W. Härdle : Applied Nonparametric Regression
P.J. Green and B.W. Silverman : Nonparametric Regression & Generalized Linear Models
J.L. Horowitz : Semiparametric methods in Econometrics
T. Hastie and R. Tibshirani : Generalized Additive Models
P. McCullagh and J. Nelder: A Generalized Linear Models, 2 edn,
D.W. Scott : Multivariate Density Estimation:Theo., Prac. & Visualization
M.P. Wand and M.C. Jones: Kernel Smoothing
A. Yatchew : Semiparametric Regression for Applied Econometrician

STAT 305 : Operations Research (4)

Definition and Scope of Operations Research. (1)

Linear programming – an introduction. (4)

Decision-making under uncertainty and risk, use of different criteria. 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 2x2, 2xm and mxn games. (6)

Analytical structure of inventory problems, EOQ formula of Harris & Wilson, its sensitivity analysis and extensions allowing quantity discounts and shortages. Production inventory model. Models with random demand, the static risk model. P and Q- systems with constant and random lead times. Exact analysis of Q-system under Poisson demand. Airline problem. ABC analysis. (11)

Queueing models – specification and effectiveness measures. Steady-state solutions of M/M/1, M/M/c and M/M/c/N, M/G/1 models, Machine interference problem, Waiting time problems, Little's formula. (8)

Integer programming – all integer and mixed integer linear programming problems,

Gomory's cutting plane method, Branch and Bound method, Balas algorithm for zero-one programming (5)

Replacement problems – Deterministic models, Preventive replacement policies (cost and availability criteria), Staffing Problem (5)

References :

H.A. Taha : Operational Research

F.S. Hillier & G.J. Leiberman : Introduction to 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

G. Hadley and TM Whitin : Analysis of Inventory Systems

L. Kleinrock : Queueing Systems

Sasieni, Yaspan & Friedman : Operations Research

Sasieni & Achoff : Operations Research

I. B. Gertsbakh : Reliability Theory with Appl. to preventive maintenance

STAT 306 :Biostatistics I(4)

Survival Analysis (25)

Introduction.Basic functions and Models.Censoring and Truncation. (3)

Parametric univariate estimation : Standard models – exponential, Weibull, log-logistic, lognormal and Gamma. (2)

Nonparametric univariate estimation : Actuarial, Kaplan-Meier and Nelson-Aalen estimators. (5)

Tests of equality of survival functions :Gehan's and Mantel-Haenszel tests. (3)

Semiparametric regression models:Cox proportional hazard model – estimation, tests,diagnostics. (5)

Additive Models. Accelerated Models (3)

Competing Risk and Multivariate Survival models. (2)

Frailty Models. (2)

Cohort and Case-Control Studies (15)

Alternative study designs	(1)
Prospective and retrospective studies	(1)
Types of bias	(2)
The case-cohort study	(2)
Nested cohort studies	(2)
Case crossover studies	(2)
Strategies for confounding	(2)
Matched analysis	(2)
Mantel Haenszel methods	(1)

References :

R.G.Miller	:	Survival Analysis
P.J.Smith	:	Analysis of Failure and Survival Data
J.D.Kalbfleisch&R.L.Prentiice	:	The Statistical Analysis of Failure Time Data, 2nd ed.
J.P.Klein&M.L.Moeschberger	:	Survival Analysis : Techniques for Censored and Truncated Data
D.J. Kleinbaum & M.Klein	:	Survival Analysis – A Self-Learning Text
Breslow NE, Day NE		Statistical Methods in Cancer Research Vols I & II. IARC Scientific Publication

STAT 307 : Astrophysics and related data sources (4)

Basic Background: Elementary radiative transfer equations, absorption and emission, atomic processes. Distance measurement in Astronomy. Hubble's law. (15)

Spectral Classification of Stars: Saha's equation, Harvard System, Absolute and apparent magnitude, Mass luminousity relation, Parallax. (5)

Stellar Structure, Polytropic and homologous models Evolution of Stars: Observational basis, Sources of stellar energy, Hertzsprung-Russell diagram, evolution of low and high mass stars, Chandrasekhar limit. (5)

Stellar populations- Galactic and Globular Clusters. (3)

Galaxies- Classification-surface brightness profile-fundamental plane and its significance-Rotation curves-Missing mass and dark matters. (5)

Astronomical Measurement Errors: Statistical issues and problems. (5)

Data archives and Virtual Observatories. (2)

References:

G.J. Babu & E.D. Feigelson	:	Astrostatistics
K.D. Abhyankar	:	Astrophysics: Stars and Galaxies
A.N. Cox	:	Astrophysical Quantities
W.R. Oegerie & M.J. Fitchell	:	Clusters of galaxies
B. Basu et al.	:	An Introduction to Astrophysics

Semester IV

STAT 401 : Stochastic Processes & Time Series Analysis (2+2)

Stochastic Processes (20)

Renewal Theory: renewal processes, renewal function, elementary renewal theorem, applications, inspection paradox, asymptotic normality of a renewal process. (6)

Blackwell's and key renewal theorems (statements) in non-lattice and lattice cases, applications. (2)

Alternating renewal processes, applications to limiting excess and age. Delayed renewal processes; equilibrium renewal processes. (4)

Renewal reward processes, applications. (2)

Brief discussion of jump-Markov processes: conservativeness, embedded discrete-time Markov chain, transition probabilities, Chapman-Kolmogorov equations, holding times, transition rates, Kolmogorov backward and forward equations, stationary distributions. Examples: pure birth, birth-and-death chains. (6)

Time Series Analysis (20)

Introduction : Classical Models, Smoothing Techniques – exponential and Holt-Winters methods. (3)

Evolutionary and Stationary time series. Autocorrelation and partial autocorrelation functions. Box-Jenkins Model. Tests for Unit Roots. (8)

Volatility : ARCH, GARCH models – their variants. (5)

Analysis in the frequency domain. (3)

Forecasting. (1)

References :

S.Karlin & H.M.Taylor : A First Course in Stochastic Processes

J. Medhi : Stochastic Process

D.R. Cox : Renewal Theory

S.Ross : Stochastic Process

A.K.Basu : Stochastic Process

P.G.Hoel, S.C.Port & C.J.Stone : An Introduction to Stochastic Process

R.N.Bhattacharyya & E. Waymire : Stochastic Processes and Applications

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

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

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

A.Pankratz : Forecasting with Univariate Box-Jenkins Model

G. Janacek and L. Swift : Time Series –Forecasting, Simulation, Applications

STAT 402 : Advanced Data Analytic Techniques (4)

Resampling Techniques (10)

Permutation tests

Jackknife and Bootstrap-methods for estimating bias, standard error and distribution function based on iid random variables.

Bootstrap confidence intervals

Missing data analysis (10)

Informative or non-informative missingness; MCAR, MAR and MNAR.

Complete case / Available case estimation

Hot and cold deck imputation; MICE.

EM & MCEM algorithms

Advanced Regression (20)

Longitudinal regression – Cohort vs longitudinal effect, Bias and efficiency. Robust and parametric estimation -Weighted least-squares; Robust standard error estimation. ML and REML.Marginal, subject specific and transition models for continuous, binary and count outcomes.Concept of GEE. (12)

Linear Mixed Models and Generalised Linear Mixed Models (4)

Generalised Additive Models (4)

References :

J.J.Faraway	:	Linear Models with R
J.J.Faraway	:	Extending the Linear Model with R
D.Ruppert et al.	:	Semiparametric Regression
R.J.A.Little&D.B.Rubin	:	Statistical Analysis with Missing Data
C.K.Enders	:	Applied Missing Data Analysis
M.A.Tanner	:	Tools for Statistical Inference
G.J.McLachlan&T.Krishnan	:	The EM Algorithm and Extensions
B.Efron&R.J.Tibshirani	:	An introduction to bootstrap
B.Efron	:	The jackknife, the bootstrap, and other resampling plans
B.Efron	:	Bootstrap methods – another look at jackknife
J.Shao&D.Tu	:	The Jackknife and Bootstrap
P.J. Diggle et. al.	:	Analysis of Longitudinal Data (2^{nd}ed).

Elective - 2

STAT 403: Probability III (4)

Uniform integrability, applications. (5)

Infinite product spaces, probability measures on infinite products: Ionescu-Tulcea's theorem, Kolmogorov's consistency theorem. (5)

Conditional expectations and their properties (with proofs).Regular conditional probabilities and distributions. Sufficiency. Factorization criterion. (20)

Discrete parameter martingales: filtrations, martingales, sub-, super-, reversed martingales,

examples, maximal inequality, upcrossings inequality, convergence theorems, closability and uniform integrability, convergence in L^p, Doob decomposition, stopping times, optional sampling. Applications. (20)

References :

Y.S. Chow & H. Teicher : Probability Theory: Independence, Interchangeability, Martingales, 3rd ed.

S. Resnick : A Probability Path,Birkhäuser; 5th ed.

D. Williams : Probability with martingales

K.L. Chung : A Course in Probability Theory, 3rd ed.

K. B. Athreya & S. N. Lahiri : Probability Theory

R.J. Serfling : Approximation Theorems of Mathematical Statistics

P. Billingsley : Probability and Measure

STAT 404 : Applied Stochastic Models (4)

Majorization and stochastic order relations. Applications in Probability, Statistical inference, Reliability, Economics, and Finance. (15)

Risk-free and risky assets: examples. Present valuation. Valuation by expectation under risk. (7)

Basic portfolio management, mean-variance efficient frontiers. Utilities, Value-at- risk. Capital assets pricing models. (7)

Self-financing portfolios in finite markets. Martingales and martingale differences (definitions and main results without proofs), connections with risk-neutral probabilities. Fundamental theorems of asset pricing. Basic ideas of replication, hedging. (15)

Pricing of European options. Cox-Ross- Rubinstein Binomial model. Geometric Brownian motion; Black-Scholes model. Brief mention of exotic options. (6)

References:

A. W. Marshall, I. Olkin & B. Arnold : Inequalities : Theory of Majorization and its Applications (2nd ed)

M. Shaked.& J. G. Shantikumar : Stochastic Orders

M. Capinski & T. Zastawniak: Mathematics for Finance

S. M. Ross : An Elementary Introduction to Mathematical Finance

D. Kennedy : Stochastic Financial Models

S. Resnick : A Probability Path

N. Privault : Stochastic Finance: An Introduction with Market Examples

A. N. Shiryaev : Essentials of Stochastic Finance: Facts, Models, Theory

STAT 405 : Advanced Parametric Inference (4)

Behrens-Fisher problem and its generalisation. Scheffe's solution in the univariate case and its multivariate extension. Welch's approach. A special noncentral F distribution, Stein's two-step procedure and its applications, Banerjee's test. (8)

Invariant statistical decision problem and invariant decision rules. Equivariant estimation. Best invariant estimator in location and scale families. Invariance in hypothesis testing, Uniformly most powerful invariant tests, Invariance of Hotelling's T^2. (8)

Hypothesis testing problems under order restricted parameters (3)

Inference for high dimensional data (4)

Multiple Hypothesis Testing: FWER, Bonferroni's procedure, Holm's procedure, Hochberg's procedure, FDR, Benjamini-Hochberg's procedure, multiple testing under dependence set up, multiple testing using weights. (9)

Shrinkage Estimation:

James-Stein Estimator, Empirical Bayesian viewpoint, Ridge, the Lasso (8)

References :

E.L.Lehmann& G. Casella : Theory of Point Estimation

E.L.Lehmann& J.P. Romano : Testing Statistical Hypotheses

R.J.Serfling : Approximation Theorems of Mathematical Statistics

R.Muirhead : Aspects of Multivariate Statistical Theory

Y.Hochberg&A.C.Tamhane : Multiple Comparisons Procedures

R.Dykstra, T.Robertson&F.T.Wright: Advances in Order restricted Statistical Inference

B. Efron :Large-Scale Inference: Empirical Bayes Methods for Estimation, Testing, and Prediction

G.James, D.Witten,T. Hastie and R. Tibshirani : An Introduction to Statistical Learning: with

Applications in R

STAT 406 :Biostatistics II (4)

Clinical Trials (25)

Introduction, Ethical issues in clinical trials, Types of clinical trials, Sample size determination, Group sequential monitoring. (10)

Randomized clinical trials: Randomization for balancing treatment assignments (random allocation rule, truncated binomial design, biased coin designs), Incorporating covariate information. (7)

Randomization to favor the better performing treatments for binary responses (play-the-winner and randomized-play-the–winner rules). (5)

Randomization to favor the better performing treatments for continuous and categorical responses (3)

Causal Inference (15)

The potential outcome framework and counterfactuals (1)

Estimation and inference for average treatment effects (2)

Confounding (2)

Graphical models - Structural Equation Models (3)

Propensity scores, (3)

Unmeasured confounding: instrumental variables. (3)

Sensitivity Analysis (1)

References :

S.Piantadosi : Clinical Trials - A Methodologic Perspective

B.S.Everitt&A.Pickles : Statistical Aspects of Design & Analysis ofClinical Trials

S.J.Pocock : Clinical Trials

J.Whitehead : The Design and Analysis of Sequential Clinical Trials

W. F. Rosenberger & J.M. Lachin: Randomization in Clinical Trials- Theory and Practice

Imbens, G.W. and Rubin, D.B. Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction

STAT 407 : Statistical Analysis of Big Data (4)

Machine learning: Supervised and unsupervised (2)

The 5 v's of a big data problem, The curse of dimensionality: Application of ICA, Prediction accuracy vs bias (5)

Measurement of model fit : Cross Validation and information theoretic criteria (2)

Generalization of Linear Regression – Shrinkage methods: Ridge Regression and LASSO (7)

Partial least squares (4)

Additive models (4)

Nonlinear models (4)

Classification Trees and Random Forests (3)

Classification using a separating hyperplane :The maximal margin classifier and separability, Support Vector Machine, Data piling in high dimension, Case of multiple classes. (6)

Computer Architecture for Big Data (3)

References:

T. Hastie, R. Tibshirani & J. Friedman : The Elements of Statistical Learning

B.L. Friedman, et al. : Classification and Regression Trees

R. Stephen & E. Richard : Independent Component Analysis – Principles and Practice

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

Elective - 3

STAT 408 : Advanced Probability (4)

Weak convergence of probabilities on Polish spaces: Portmanteau theorem, tightness, Prohorov's theorem. Weak convergence in C([0,1]): co-ordinate process, Arzela-Ascoli theorem, conditions for tightness. (12)

Brownian motion on [0,1], on [0,∞), properties; limit theorems, Brownian bridge, invariance principles. Skorohod's representation. Applications. (20)

Brief introduction to diffusions. (8)

Brief discussion of Point processes and random measures with special reference to Poisson random measures. (10)

References:

D. Freedman : Brownian motion and diffusions

P. Billingsley : Convergence of probability measures.

K.R. Parthsarathy : Probability measures on metric spaces.

R.L. Schilling & L. Partzsch : Brownian motion.

De Gruyter : An introduction to stochastic processes

P. Mörters & Y. Peres : Brownian motion.

STAT 409 : Advanced Nonparametric Inference (4)

Hodges-Lehmann Estimators and their properties. (4)

Density Estimation (4)

Estimation of functionals, Measures of robustness, sensitivity curves and Influence functions. Breakdown point (4)

M and M_m estimators (2)

Nonparametric regression, Rank Regression. (6)

Bivariate Sign Test and Rank Permutation Principle (4)

Distribution free tests for ordered alternatives, Bivariate association problems (4)

Contiguity, Le Cam's Lemmas. Linear Rank Statistic and its asymptotic distribution under null and different local alternatives. (6)

Nonparametric inference for high dimensional data (6)

References :

J.Hajek, P.K. Sen & Z.Sidek : Theory of Rank Tests

R.H.Randles &D.A.Wolfe : Introduction to the theory of nonparametric statistics

T.P.Hettmansperger : Statistical Inference based on ranks

E.L.Lehmann : Theory of Point Estimation

P.J. Huber &E.M. Ronchetti : Robust Statistics (2nd Ed)..

F.R. Hampel, E.M. Ronchetti, P.J. Rousseeuw & W.A. Stahel. : Robust Statistics: The Approach Based on Influence Functions.

R.A. Maronna, R.D. Martin &V.J. Yohai :Robust Statistics: Theory and Methods.

STAT 410 : Reliability Theory (4)

Reliability concepts and measures, components and systems, coherent systems, reliability of coherent systems. (3)

Life-distributions, reliability function, hazard rate, Mean residual life, common univariate life distributions, Mixture distribution, Convolution distribution, Bivariate exponential. (7)

Notions of ageing – IFR, IFRA, NBU, DMRL and NBUE classes and their duals, preservation of such classes under reliability operations, Loss of memory property, Partial ordering of life distributions. (6)

Censoring; reliability estimation based on failure times from variously censored life-tests data for parametric families. (5)

Kaplan – Meier estimation of reliability curve, Greenwood formula, Non – parametric methods for comparison of several reliability curves, Log rank tests. (5)

Regression models in reliability, Cox PH and Accelerated failure time models; Estimation of parameters and diagnostics. (5)

Types of warranty; modelling; warranty cost analysis. Warranty prediction. (5)

Concept of maintenance; Maintenance and replacement models; Availability; (4)

References:

R.E. Barlow & F. Proschan : Statistical Theory of Reliability and Life- Testing

J.F. Lawless : Statistical Models and Methods of Life-time data

L.J. Bain & M. Engelhardt : Statistical Analysis of Reliability and Life- testing Models

S. Zacks : Introduction to Reliability Analysis: Probability Models and Statistical Methods

J.D. Kalbfleisch &R.L. Prentice : The Statistical Analysis of Failure time data, 2nd ed.

P.J. Smith : Analysis of failure and survival data

C.D. Lai & M. Xie : Stochastic Ageing and Dependence for Reliability

I.B. Gertsbakh : Reliability Theory with Applications to Preventive Maintenance

W. Buschke and P.Murthy : Warranty cost analysis.

STAT 411 : Directional and Spatial Statistics (4)

Examples of Directional Data (DD) in diverse fields (3)

Graphical representations and Summary measures. (4)

Characterizations and Constructions of probability distributions on the circle and sphere. (10)

Statistical inference in one and several von Mises populations. (6)

Circular Goodness-of-Fit tests. (2)

Theory of Spatial point process and spatio-temporal point process. (4)

Spatial clustering, Complete spatial randomness and related tests (7)

Spatial cross correlation. (4)

References:

N.I. Fisher, et al. : Statistical Analysis of Spherical Data

S.R. Jammalamadaka & A. SenGupta. : Topics in Circular Statistics

K.V. Mardia. : Statistics of Directional Data

G.S. Watson. : Statistics

G.L. Gaile & J.C. Willmott : Spatial Statistics and Models

N. Cressie : Statistics for Spatial Data

P Diggle : Statistical Analysis of spatial and spatio-temporal point patterns

STAT 412 : Statistical Genetics (4)

Introduction to genetics, Mendel's Laws (4).

Random Mating, Hardy-Weinberg Equilibrium (2).

Estimation of allele frequencies from genotype and phenotype data (with applications of the EM algorithm) (4).

Inbreeding, Mutation, Selection (5).

Pedigree analysis, Familial aggregation, segregation and linkage analysis using likelihood and ASP method (10).

Linkage disequilibrium (2).

Genetic association tests based on case-control data and family data (TDT, Sib-TDT) (10).

Genome wide association study and related issues (3).

References

B.H. Liu : Statistical Genomics Linkage, Mapping, and QTL Analysis

B. Neale, M. Ferreira, S. Medland & D. Posthuma (eds.) : Statistical Genetics: Gene MappingThrough Linkage and Association

N.M. Laird & C. Lange: The Fundamentals of Modern Statistical Genetics

M. Lynch & B. Walsh : Genetics and Analysis of quantitative traits.

J. Felsenstein : Inferring Phylogenies

Z.Yang : Computational Molecular Evolution, Oxford University Press

STAT 413 : Econometrics (4)

Single-equation models – censored data, measurement errors, lagged variables. (8)

Generalized Method of Moments (2)

Simultaneous Equations – identification & estimation. SUR models. (12)

Analysis of Panel Data (6)

Causality: Granger causality, VAR and VARMA models. Exogeneity testing. Error Correction Model. (7)

Cointegration. (5)

References :

J. Johnston : Econometric Methods

G.G. Judge, et.al. : The Theory and Practice of Econometrics (2nded.)

W. Greene : Econometric Analysis

E. Malinvaud : Statistical Methods in Econometrics
B.M. Baltagi : Econometric Analysis of Panel Data
M.D. Intrilligator, R.G. Bodkin & C.Hsiao : Eco. Models, Techniques and Applications
G.S. Maddala & I.M. Kim : Unit Roots, Cointegration, and Structural Change

Choice-based course offered by the department

Statistical Methods (4)

Study design. Graphical representation of data. Features of frequency distribution, summary measures. Problems with outliers and extremes. Association, dependence, causality. Correlation and regression in bivariate and multivariate setups. Discrete data analysis. (16)

Probability. Basic results. Conditional probability and Bayes theorem. Random variables- expectation and variance. Discrete & Continuous Probability models. Computation of probability in various applied research. (17)

Basics of Statistical inference. Estimation and Hypothesis testing problems in special setups. Applications of statistical inference in applied research. (17)

References:

Goon A.M., Gupta M.K. and Dasgupta B. : Fundamentals of Statistics, Vol. I& II, 8th Ed.
Miller, Irwin and Miller, Marylees : John E. Freund's Mathematical Statistics with Applications, (7th Ed.),
Mood, A.M. Graybill, F.A. and Boes, D.C. : Introduction to the theory of Statistics, 3rd Ed.
Hogg, R.V., Tanis, E.A. and Rao J.M.: Probability and Statistical Inference, 7th Ed,
Ross, S. : A First Course in Probability, Prentice Hall.
Dunn, O.J. : Basic Statistics: A primer for the Biomedical Sciences.