UNIVERSITY OF CALCUTTA

Notification No. CSR/ 61 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus and Regulations of Two-Year (Four-Semester) M.Sc. Course of Study in Statistics under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018

(Debabrata Manna)
Deputy Registrar (Acting)

UNIVERSITY OF CALCUTTA

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

2018

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 60% 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 2018-19 will be same as the comprehensive and uniform regulations of Calcutta University.

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

1. Each semester will have a number of courses as detailed below. Each course will comprise of either a Theoretical component or a Practical component or both.
2. The end-semester examinations for the theoretical papers will be held after the completion of the classes of that semester. **Twenty percent** of the marks in each theoretical 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(s). The Practical papers 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 papers (excluding internal assessment marks) with $\leq$ 40 marks and 41-50 marks will be of 1½ hours and 2 hours duration, respectively.

5. Each credit point is equivalent to 10 marks in the examinations (except for the choice based courses and the project work in the 3rd semester).
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 1 or 2 courses can sit for a supplementary examination in the concerned course to be held usually within six months of the original examination. Students can however continue their studies in the higher semesters. Students failing in a supplementary examination can have a final chance of clearing the paper during the regular examination of the paper in the following session. However, students unable to clear the supplementary examination in any course in the 3rd or 4th semesters may be allowed to take a second supplementary examination within six months of the end of the 4th semester.
8. Students failing to obtain pass marks in more than 2 courses in a semester will be deemed to have failed in the semester as a whole and will need to clear that semester in subsequent sessions before moving on to the next semester.
9. Students will be required to select 1 elective paper in the 3rd semester and 3 elective papers in the 4th semester. These are detailed in the syllabus of the respective semester. Some of the elective papers may be pre-requisites/ requisites for other elective papers (as mentioned in the syllabus).
10. 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 M.Sc. Examination in Statistics

(Credit points and marks on two right-hand columns are shown as Theoretical credits (marks) + Practical credits (marks))

Semester I : Total credits = 25 (Total Marks = 250)

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 101 :	Analysis I	4 + 0	40 + 0
STAT 102 :	Probability I	4 + 0	40 + 0
STAT 103 :	Statistical Inference I	4 + 1	40 + 10
STAT 104 :	Linear Algebra & Linear Models	4 + 1	40 + 10
STAT 105 :	Sample Surveys & Demography	3 + 1	30 + 10
STAT 106 :	R Programming	0 + 3	0 + 30

Semester II : Total credits = 25 (Total Marks = 250)

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 201 :	Probability II	3 + 0	30 + 0
STAT 202 :	Multivariate Analysis	4 + 1	40 + 10
STAT 203 :	Statistical Inference II	3 + 1	30 + 10
STAT 204 :	Regression Analysis I	3 + 1	30 + 10
STAT 205 :	Design of Experiments	3 + 1	30 + 10
STAT 206 :	Time Series Analysis & Development Statistics	4 + 1	40 + 10

Semester III : Total credits = 25 (Total Marks = 250)

In this semester, students will be required to select one elective paper 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. *Some of the elective papers are pre-requisites of certain elective papers*

(as discussed in Semester IV) to be chosen in the 4th semester and hence are to be viewed accordingly.

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 301 :	Statistical Inference III	3 + 1	30 + 10
STAT 302 :	Regression Analysis II	3 + 1	30 + 10
STAT 303 :	Applied Multivariate Analysis	2 + 1	20 + 10
STAT 304-308 :	Elective 1	3 + 1 or 4 + 0	30 + 10 or 40 + 0
	Choice based 1	4	50
	Choice based 2	4	50
	Project Work	0 + 2	(evaluation at the end of 4th Semester)

Choice of Elective papers :

Elective 1 : *Any one from the following*

- STAT 304 : Analysis II (*pre-requisite* for STAT 415)
- STAT 305 : Applied Bayesian Methods
- STAT 306 : Operations Research (*pre-requisite* for STAT 419)
- STAT 307 : Demography
- STAT 308 : Survival Analysis (*pre-requisite* for STAT 405 & STAT 411)

Semester IV : Total credits = 25 (Total Marks = 250)

In this semester, students will be required to select one elective paper from each of three 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
STAT 401 :	Stochastic Processes	3 + 0	30 + 0
STAT 402 :	Adv. Data Analytic Techniques	3 + 2	30 + 20

STAT 403-408 :	Elective 2	3 + 1 or 4 + 0	30 + 10 or 40 + 0
STAT 409-414 :	Elective 3	3 + 1 or 4 + 0	30 + 10 or 40 + 0
STAT 415-420 :	Elective 4	3 + 1 or 4 + 0	30 + 10 or 40 + 0
STAT421 :	Project Work	0 + 5	0 + 50

Choice of Elective Papers :

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

STAT 403 : Probability III
STAT 404 : Advanced Parametric Inference
STAT 405 : Clinical Trials and Bioassay (*requisite* STAT 308)
STAT 406 : Statistical Quality Management
STAT 407 : Statistical Analysis of Big Data
STAT 408 : Actuarial Statistics

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

STAT 409 : Applied Stochastic Models
STAT 410 : Nonparametric Methods
STAT 411 : Epidemiology (*requisite* STAT 308)
STAT 412 : Reliability Theory
STAT 413 : Directional and Spatial Statistics
STAT 414 : Regression Designs

Elective 4 : ***Any one from the following***

STAT 415 : Advanced Probability (*requisite* STAT 304)
STAT 416 : Sequential and Semiparametric Methods
STAT 417 : Econometrics
STAT 418 : Statistical Genetics
STAT 419 : Advanced Operations Research (*requisite* STAT 306)
STAT 420 : Astrophysics and related data sources

Detailed Syllabus

Semester I

STAT 101 : Analysis I (4+0)

Sequences, subsequences, convergence, divergence, bounded sequences, limits superior and inferior, monotone sequences, Cauchy sequences, completeness. (9)

Bounded and unbounded subsets of the line, intervals, closed and open sets, characterizations, limit points, closures, interiors. Denseness. Compact sets. Heine-Borel, Bolzano-Weirstrass Theorems (statements). (8)

Functions : limits, continuity, uniform continuity, intermediate value theorem, differentiability; mean value theorem, Taylor's theorem (statement), extrema. (8)

Series of real numbers. (3)

Sequences and series of functions, uniform convergence, power series, term-by-term differentiation and integration. (6)

Multivariate calculus: partial, directional and total derivatives, mean value theorem. (6)

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+0)

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

Measures, finite, sigma-finite measures. Probability measures, properties. Independence of events, Borel-Cantelli lemmas. (5)

Measurable functions and properties, Generated sigma-fields. Induced measures. Compositions. Examples. (4)

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

Random variables and vectors, probability distributions, distribution functions. (2)

Convergence in measure, almost everywhere and their connection. (1)

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

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

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+1)

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: One parameter exponential family. (3**)**

Similar tests, Neyman structure, UMPU tests for composite hypotheses. (10)

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 Algebra and Linear Models (4+1)

Linear Algebra (15)

Vector spaces and subspaces, Rank and basis, Orthogonality – projections and least squares approximation, Eigen values and eigen vectors and related inequalities, Linear transformation. (15)

Linear Models (25)

Gauss Markov Model: Estimable function, error function, BLUE, Gauss Markov theorem. Correlated set-up, least squares estimate with restriction on parameters. (8)

Linear Set, General linear hypothesis – related sampling distribution, Multiple comparison techniques due to Scheffe and Tukey. (6)

Analysis of variance: Balanced classification, Fixed Effects Model, Random Effects Model and Mixed Effects Model; Inference on Variance components. (7)

Regression analysis (1)

Analysis of covariance. (3)

References :

G. Hadley : Linear Algebra

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

G. Strang	:	Introduction to Linear Algebra
D. C. Lay	:	Linear Algebra and its Applications
R. B. Bapat	:	Linear Algebra and Linear Models
A. R. Rao & P.Bhimasankaram	:	Linear Algebra :
H.Scheffe	:	The Analysis of Variance
S.R.Searle	:	Linear Models
G.A.F.Seber	:	Linear Regression Analysis
N.C. Giri	:	Analysis of Variance

STAT 105 : Sample Surveys and Demography (3+1)

Sample Surveys (15)

Probability sampling from a finite population – Notions of sampling design, sampling scheme, inclusion probabilities, Estimation of sample size. Horvitz-Thompson estimator of a population total. (5)

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)

Demography (15)

Mortality, Fertility and Migration- use of balancing equation, Measures of Migration. Undocumented migration. (4)

Growth curve models, Population Estimation and Projection- component method, Population projection by Leslie Matrix. (5)

Life tables: Distribution of life table functions and their estimates. Multiple Decrement tables. (6)

References :

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

M Spiegelman : Introduction to Demography

C.L.Chiang :Introduction to Stochastic Processes in Biostatistics

R C E Johnson & N L Johnson : Survival Models & Data Analysis

H.S.Shryock et.al. : The Methods and Materials of Demography

STAT 106 : R Programming (0+3)

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, orthonormalisation, 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.

Useful libraries: MASS, optim, maxLik, dplyr, ggplot2.

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 (3+0)

Product sigma-fields, Borel sigma-field on Euclidean spaces. Product measures. Fubini's theorem. Lebesgue measure on R^k. (4)

Convergence in distribution. Examples. Portmanteau theorem (statement and applications). Scheffe's theorem, Slutsky's theorem. (5)

Holder's, Minkowski's and Jensen's inequalities. L_p spaces, L_p-convergence of random variables, connections with other modes of convergence. (4)

Independence of random variables, their partial sums. Kolmogorov's 0-1 law. Kolmogorov's inequality. (2)

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)

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+1)

Non-central χ^2, t & F distributions – definitions and selected properties. (3)

Distribution of quadratic forms – Cochran's theorem. (5)

Sampling from Multivariate normal distribution – independence of sample mean vector and variance-covariance matrix.Wishart distribution. (4)

Distributions of partial and multiple correlation coefficients and regression coefficients, (5)

Hotelling T^2 and Mahalanobis's D^2 application in testing and confidence set construction. (3)

Multivariate linear model: estimation of parameters, tests of linear hypotheses (7)

Multivariate Analysis of variance of one and two way classified data, simultaneous confidence intervals, Multivariate Analysis of Covariance. (13)

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

STAT 203 : Statistical Inference II (3+1)

Bayesian Analysis (**10**)

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. (5)

Sequential Analysis (**7**)

Stopping variables, Sequential Tests, Wald's equation for ASN, SPRT and its properties – fundamental identity, OC and ASN, Optimality of SPRT (under usual approximation).(7)

Asymptotic Inference (13)

Consistency and Asymptotic Efficiency of Estimators, Maximum Likelihood estimators and their Large sample properties. (7)

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 I (3+1)

Building a regression model: Transformations – Box-Cox and Box-Tidwell models, Stepwise regression, Model selection (adjusted R^2, cross validation and Cp criteria, AIC, PRESS) .(7)

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 and COVRATIO. (4)

Checking for normality: Q-Q plots, Normal Probability plot, Shapiro-Wilks test. (3)

Departures from the Gauss-Markov set-up : Heteroscedasticity and Autocorrelation – detection and remedies. (8)

References :

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

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

G.G. Judge, W.E. Griffith, R.C. Hill,
W. Lutkepohl & T.C. Lee : The Theory and Practice of Econometrics (2nd ed.)

T.P. Ryan : Modern Regression Methods (2nd ed.)

J.O. Rawlings, S.G. Pantula & D.A. Dickey : Applied Regression Analysis: A Research Tool

S. Chatterjee & A.S. Hadi : Regression Analysis by Example

STAT 205 : Design of Experiments (3+1)

Block Designs: Connectedness, Orthogonality, Balance and Efficiency; Resolvable designs. Properties of BIB designs, Designs derived from BIB designs. (7)

Intrablock analysis of BIB, Recovery of inter-block information in BIB designs; Row column and Youden Square designs, Missing plot technique. Elementary ideas of Lattice and PBIB designs. (7)

Construction of mutually orthogonal Latin Squares (MOLS); Construction of BIBD through MOLS and other ways. (5)

Factorial designs: Analysis, Confounding and balancing in Symmetric Factorials. (8)

Response Surface Designs. (3)

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

STAT 206 : Time Series Analysis and Development Statistics (4+1)

Time Series Analysis (26)

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. (6)

Multivariate Time Series Models : VAR and VARMA models. (3)

Forecasting. (2)

Analysis in the Frequency Domain : The Sprectum and Periodogram Analysis. (4)

Development Statistics (14)

Concept of economic development – role of statistics. National and international statistical systems. National accounts – estimation of national income. (4)

Measurement of Poverty, Inequality and Unemployment. (8)

Development indices. (2)

References :

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

CSO (2007) : National Accounts Statistics – Sources and Methods

A.Sen : Poverty and Inequality

Y.P.Chaubey : Poverty Measurements : issues, approaches and indices

UNO : Yearly Human Development Reports

Semester III

STAT 301 : Statistical Inference III (3+1)

Decision Theory (**15**)

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. (6)

Bayes rules, Extended Bayes, Generalized Bayes and Limit of Bayes rules, Admissibility of Bayes rule. (5)

Minimax rules, Method for finding minimax rules. (4)

Nonparametric Methods (**15**)

Elementary concepts of U-statistics and Linear Rank Statistics, Single sample location, location cum symmetry and goodness-of-fit problem. (5)

Two-sample location, scale and homogeneity problems, Multi-sample location problem, Bivariate association problem. (6)

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 : Regression Analysis II (3+1)

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. (3)

Extensions of GLMs: Zero inflated Poisson models,.Joint modeling of mean and variance, Concept of Generalized Additive Models (GAM). (8)

References :

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 303 : Applied Multivariate Analysis (2+1)

Clustering: Hierarchical clustering for continuous and categorical data- different choices of proximity measures, Agglomerative and Divisive algorithms, K-means clustering optimum choice of the number of clusters. (6)

Classification and discrimination procedures: Discrimination between two known populations – Bayes, Minimax and Likelihood Ratio procedures. Discrimination between two multivariate normal populations. Sample discriminant function. Likelihood ratio rule. Probabilities of misclassification and their estimation. Classification of several populations.Fisher's method fordiscriminating among several populations. (8)

Principal Component Analysis: Population and sample Principal components and their uses. Plotting techniques (3)

Factor Analysis: The orthogonal factor model, Estimation of factor loading, Factor rotation, Estimation of Factor scores, Interpretation of Factor Analysis. (6)

References :

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

N.C.Giri : Multivariate Statistical Inference

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

A.M.Khirsagar : Multivariate Analysis

D.F.Morrison : Multivariate Statistical Methods

R.J.Muirhead : Aspects of Multivariate Statistical Theory

G.A.F.Seber : Multivariate Observations

S.C.Sharma : Applied Multivariate Techniques

Elective Papers

Elective - 1

STAT 304 : Analysis II (4+0)

Examples of infinite-dimensional vector spaces. Norms and Inner products on vector spaces, orhtogonality. Seminorms and quotient spaces. (4)

Metric spaces : open, closed, closures, interiors, dense sets, sequences and limits, subsequences, completeness, compactness, separability and consequences. Functions and continuity, uniform continuity, connectedness. (15)

Hilbert spaces, orthonormal basis, applications to Statistics. Brief introduction to Fourier Analysis. (6)

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 . (15)

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 (8th ed.)
G.F. Simmons : Introduction to Topology and Modern Analysis

STAT 305 : Applied Bayesian Methods (3+1)

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.

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 Shrinkage and Bayesian Estimation, Empirical Bayes Estimation (with examples), Comparison of Hierarchical vs. Empirical Bayes.

Bayesian Probit and Logistic Regression (Multi-category Ordinal Response).

Multinomial-Dirichlet model.

Nonparametric Bayes.

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

STAT 306 : Operations Research (3+1)

Definition and Scope of Operations Research. (1)

Linear programming – an introduction. (3)

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 2×2, 2×m and m×n games. (6)

Analytical structure of inventory problems, EOQ formula of Harris & Wilson, its sensitivity analysis and extensions allowing quantity discounts and shortages. Models with random demand, the static risk model. P and Q- systems with constant and random lead times. ABC analysis. (6)

Queueing models – specification and effectiveness measures. Steady-state solutions of M/M/1, M/M/c and M/M/c/N models, Machine interference problem, Waiting time problems, Little's formula. (5)

Integer programming – all integer and mixed integer linear programming problems, Gomory's cutting plane method, Branch and Bound method, Balas algorithm for zeroone programming (5)

Replacement problems – Deterministic models, Preventive replacement policies (cost and availability criteria), Staffing Problem (4)

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

L. Kleinrock : Queueing Systems

Sasieni, Yaspan & Friedman : Operations Research

Sasieni & Achoff : Operations Research

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

STAT 307 : Demography (3+1)

Definition of concepts: Life and Death, Death Rates- age, space and cause specific. Adjusted death rates, Disease burden- DALY & QALY. (8)

Natality: Birth rates- age-sex adjusted, Stochastic Models of fertility and Population growth, stable and quasi stable population, intrinsic growth rate. (8)

Age structured population growth:continuous analysis- Lotka's integral equation. (4)
Stochastic Models for Social and Occupational Mobility based on Markov Chains – closed and open systems, Estimation of Measures of Mobility. Manpower planning Models. (10)

References :

D.J.Bartholomew : Stochastic Models for Social Processes (3rd edition)
C.L.Chiang : Introduction to Stochastic Processes in Biostatistics
P.R.Cox : Demography
N.Keyfitz : Mathematical Demography
H.S.Shryock et.al. : The Methods and Materials of Demography

STAT 308 : Survival Analysis (3+1)

Introduction.Basic functions and Models.Censoring and Truncation. (5)
Parametric univariate estimation : Standard models – exponential, Weibull, log-logistic, log-normal and Gamma. (2)
Nonparametric univariate estimation : Actuarial, Kaplan-Meier and Nelson-Aalen estimators. (6)
Tests of equality of survival functions :Gehan's and Mantel-Haenszel tests. (3)
Semiparametric regression models :Cox proportional hazard model – estimation, tests, diagnostics. (6)
Additive Models. Accelerated Models (4)
Competing Risk and Multivariate Survival models. (2)
Frailty Models. (2)

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

Semester IV

STAT 401 : Stochastic Processes (3+0)

Introduction, Count process. Poisson process. (3)

Renewal Theory: renewal processes, renewal function, elementary renewal theorem, applications, Blackwell's and key renewal theorems (statements), alternating renewal processes, applications to limiting excess and age. (9)

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. Examples: birth-and-death processes, branching processes (12)

Jump-Markov processes: conservativeness, transition probabilities, holding times, embedded Markov chain, Chapman-Kolmogorov equations, Kolmogorov backward and forward equations, stationary distributions. Examples: pure birth, birth-and-death chains. Applications to queueing. (6)

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

STAT 402 : Advanced Data Analytic Techniques (3+2)

Resampling Techniques (**10**)

Permutation tests (2)

Introduction to Jackknife and Bootstrap-methods for estimating bias, standard error and distribution function based on iid random variables, (3)

Standard examples (3)

Bootstrap confidence intervals (2)

Missing data analysis (10)

Informative or non-informative missingness; MCAR, MAR and MNAR. (2)

Complete case / Available case estimation (2)

Mean imputation, Hot and cold deck imputation; MICE. (4)

EM & MCEM algorithms and data augmentation techniques. (2)

Longitudinal data analysis (10)

Longitudinal regression : Cohort vs longitudinal effect, Bias and efficiency (3)

Robust estimation -Weighted least-squares; Robust standard error estimation. (2)

Parametric estimation: ML and REML. (2)

Marginal, subject specific and transition models for continuous, binary and count outcomes. (2)

Concept of GEE. (1)

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+0)

Uniform integrability, applications. (4)

Infinite product spaces, probability measures on infinite products: Kolmogorov's consistency theorem (statement). (4)

Conditional expectations and their properties (with proofs).Regular conditional probabilities and distributions. Sufficiency. Factorization criterion. (12)

Discrete parameter martingales: filtrations, martingales, sub-, super-, reversed martingales, examples, maximal inequality, upcrossings inequality, convergence theorems, closability, 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 : Advanced Parametric Inference (3+1)

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. (8)

Improved estimation of mean and dispersion under the normal set up. (7)

Behrens-Fisher problem and its generalisation.Scheffe's solution in the univariate case and its multivariate extension.Welch's approach.Stein's two-step procedure. (7)

Multiple Hypothesis Testing (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

STAT 405 : Clinical Trials and Bioassay (3+1)

Clinical Trials (20)

Introduction, Ethical issues in clinical trials, Types of clinical trials, Sample size determination, Group sequential monitoring. (9)

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). (4)

Bioassay (10)

Logic of biological assay; Dose-response relation; Quantitative and quantal responses; Feiler's theorem for fiducial limit estimation. (2)

Probit and Logit models for quantal assay; Estimation of effective dose levels from symmetric and asymmetric tolerance distribution. (4)

Problems with extreme dose level and Quantit analysis; Acute bioassay. (2)

Pool adjacent violator algorithm and Non-parametric estimation of effective dose levels. (2)

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

D.J. Finney : Statistical Methods for Biological Assay

B.J.T Morgan : Analysis of Quantal Response Data
Z. Govindarajulu : Statistical Techniques in Bioassay

STAT 406 : Statistical Quality Management (3+1)

Group control chart. Extreme value chart. Moving average and exponentially weighted moving average charts. Cu-sum charts using V-masks and decision intervals. Economic design of $\overline{X}$ - chart. (9)

Multivariate Control Charts (3)

Acceptance sampling plans for inspection by variables for two-sided specifications. Mil Std 105 plans. Continuous sampling plans of Dodge type and Wald-Wolfowitz type and their properties. Bayesian sampling plans (9)

Process Capability (4)

QM System and ISO 9001 – brief exposition. (2)

Basic concepts of 6s - DMAIC approach and the metrics used. (3)

References :

D.C. Montogomery : Introduction to Statistical Quality Control
E.R. Ott : Process Quality Control
G.B. Wetherill : Sampling Inspection and Quality Control
G.B. Wetherill & D.W. Brown : Statistical Process Control – Theory and Practice

STAT 407 : Statistical Analysis of Big Data (3+1)

Big data analysis- introduction (2)

Generalization of Linear Regression- Ridge Regression, LASSO, Principal Components Regression (6)

Partial least squares (4)

Dimension Reduction-Generalization of Principal Component Analysis- Independent Component Analysis (ICA) (7)

Generalization of Linear Discriminant Analysis- Two groups: unknown distributions, Nearest neighbor technique, Evaluating classifiers: ROC Curves. (6)

Tree based methods- Classification and Regression Trees (CART). (6)

Cosmic Microwave Background: Anisotropy, Multiple Testing- Higher Criticism Statistic. (2)

References:

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

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

A. Hyvarinen, et al. : Independent Component Analysis

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

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

STAT 308 : Actuarial Statistics (3+1)

Review of decision theory and actuarial applications.

Loss distributions: modelling of individual and aggregate losses, moments, fitting distributions to claims data, deductibles and retention limits, proportional and excess-of-loss reinsurance, share of claim amounts, parametric estimation with incomplete information.

Risk models: models for claim number and claim amount in short-term contracts, moments, compound distributions, moments of insurer's and reinsurer's share of aggregate claims.

Review of Bayesian statistics/estimation and application to credibility theory.

Experience rating: Rating methods in insurance and banking, claim probability calculation, stationary distribution of proportion of policyholders in various levels of discount.

Delay/run-off triangle: development factor, basic and inflation-adjusted chain-ladder method,alternative methods, average cost per claim and Bornhuetter-Ferguson methods for outstanding claim amounts, statistical models.

Review of generalized linear model, residuals and diagnostics, goodness-of-fit, applications.

Review of time series analysis, filters, random walks, multivariate models, cointegrated time series, non-stationary/non-linear models, application to investment variables, forecasts.

Assessment of methods through Monte-Carlo simulations.

References :

N. L. Bowers, H. U. Gerber, J. C. Hickman, D. A. Jones & C. J. Nesbitt :
Actuarial Mathematics, 2nd ed.

S. A. Klugman, H. H. Panjer, G. E. Willmotand & G. G. Venter :

Loss Models: From Data to Decisions.

C. D. Daykin, T. Pentikainen & M. Pesonen : Practical Risk Theory for Actuaries.

Elective - 3

STAT 409 : Applied Stochastic Models (4+0)

Majorization and stochastic order relations. Applications in Probability, Statistical inference, Reliability, Economics, and Finance. (10)

Risk-free and risky assets: examples. Present valuation. Valuation by expectation under risk. (3)

Basic portfolio management, mean-variance efficient frontiers. Utilities, Value-at- risk. Capital assets pricing models. (4)

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. (8)

Pricing of European options. Cox-Ross- Rubinstein Binomial model. Geometric Brownian motion; Black-Scholes model. Brief mention of exotic options. (5)

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 410 : Nonparametric Methods (3+1)

U-Statistics. (5)

Linear Rank Statistic and its asymptotic distribution under null and different local alternatives. (5)

Consistency and Asymptotic Relative efficiency.Optimality of tests. (3)

Bivariate Sign Test. (2)

Hodges-Lehmann Esimators and their properties. (3)

Measures of robustness, sensitivity curves and Influence functions. (3)

M estimators, breakdown point, Density Estimation. (6)

Rank Regression. (3)

References :

J. Hajek & 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 411 :Epidemiology (3+1)

Definition of epidemiology. Case study on John Snow and the Lambeth cholera epidemic.

Study designs: Ecological, Cross-sectional, Cohort, Case-Control and its variants. Prospective and Retrospective studies. (6)

Standard measures of Disease frequency and association based on rates and proportions. (4)

Confounding and effect modification. (2)

The design and analysis of cohort and case-control studies. (6)

The design and analysis of matched studies. (6)

Concept of causality and its measurement. (3)

Case studies. (3)

References :

K.J. Rothman & S. Geenland : Modern Epidemiology

S. Selvin : Statistical Analysis of Epidemiologic Data

D. McNeil : Epidemiological Research Methods

J.F. Jekel, J.G. Elmore & D.L. Katz : Epidemiology, Biostatistics and Preventive Medicine

N.E. Breslow & N.E. Day : Statistical Methods in cancer Research, Vol. 1, TheAnalysis of Case-Control Studies

N.E. Breslow & N.E. Day : Statistical Methods in cancer Research, Vol. 2, The Design and Analysis of Cohort Studies

S.J. Pocock : Clinical Trials

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

STAT 412 : Reliability Analysis (3+1)

Reliabilty concepts and measures, components and systems, coherent systems, reliability of coherent systems. (4)

Life-distributions, reliability function, hazard rate, Mean residual life, common univariate life distributions – exponential, weibull, gamma, etc..Bivariate exponential. (6)

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)

Reliability estimation based on failure times from variously censored life-tests data for parametric families. (4)

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)

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

STAT 413 : Directional and Spatial Statistics (3+1)

Examples of Directional Data (DD) in Astronomy. (2)
Graphical representations and Summary measures. (3)
Characterizations and Constructions of probability distributions on the circle and sphere. (7)
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 (6)
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 314 : Regression Designs (3+1)

Regression Designs (10)
Optimum Regression Designs (10)
Mixture Experiments (10)

References:

G.E.P. Box & N.R. Draper : Empirical Model Building and Response Surfaces

A.I. Khuri & J.A. Cornell	:	Response Surfaces
V.V. Fedorov	:	Theory of optimal experiments
S.D. Silvey	:	Optimal design
F. Pukelsheim	:	Optimal design of experiments
J. Cornell	:	Experiments with Mixtures

Elective - 4

STAT 415 : Advanced Probability

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. (10)

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

Brief introduction to diffusions. (10)

References:

D. Freedman	:	Brownian motion and diffusions
P. Billingsley	:	Convergence ofprobabilitymeasures.
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 416 : Sequential and Semiparametric Methods (3+1)

Sequential Methods (20)

Generalised Behrens Fisher problem, Fixed width interval estimation, Partial Sequential tests.

Semiparametric Models and their Analyses (10)

Single-Index-Models.Generalised Partial Linear Models.Generalized Additive Models. Different types of likelihood functions. Categorical data and related tests of significance.

References :

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

D. Sigmund : Sequential Inference

J. Berger : Statistilca Decision Theory - Foundation, Concepts & Methods

B.K. Ghosh : Sequential Tests of Statistical Hypotheses

STAT 417 : Econometrics (3+1)

Single-equation models – censored data, measurement errors, lagged variables. (7)

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

Analysis of Panel Data (5)

Granger causality, Exogeneity testing. Error Correction Model. (4)

Cointegration. (2)

References :

J. Johnston : Econometric Methods

G.G. Judge, et.al. : The Theory and Practice of Econometrics (2^{nd}ed.)

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

STAT 418 : Statistical Genetics (3+1)

Introduction to genetics (5)

Gene mapping, sequence data, population genetics and coalescent theory (7)

Phylogeny reconstruction (2)

Pedigree analysis (3)

Familial aggregation, segregation and linkage and association (6)

Genetic epidemiology, role of genetic factors in human diseases (4)

Analysis of complex and quantitative traits (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 419 : Advanced Operations Research (3+1)

M/G/1 queue and Pollazcek-Khinchine result. Steady-state solutions of $M/E_k/1$ and $E_k/M/1$ queues, Bulk arrival and bulk service queues. (6)

Traveling salesman problem - Branch and Bound method, Simulated annealing. (4)

Project management and Network analysis - PERT and CPM, Different time estimates - slack time, critical path, LP formulation of network problems, crashing of activities, Flow along network, Ford – Fulkerson's algorithm, Dijkstra's algorithm. (6)

Non-linear programming – multivariate optimization with inequality constraints. Kuhn-Tucker conditions. Convex programming, Quadratic Programming – Wolfe’s algorithm. (7)

Dynamic programming and its applications in solving various OR problems . (7)

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
L.Kleinrock	:	Queueing Systems
R. V. Hartley	:	Operations Research – A Managerial Emphasis

STAT 420 : Astrophysics and related data sources (3+1)

Basic Background: Elementary radiative transfer equations, absorption and emission, atomic processes. Distance measurement in Astronomy. Hubble's law. (8)

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. (2)

Galaxies- Classification-surface brightness profile-fundamental plane and its significance-Rotation curves-Missing mass and dark matters. (4)

Astronomical Measurement Errors: Statistical issues and problems. (4)

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

Choice-based course offered by the Department of Statistics

Statistical Methods (4+0)

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 andmultivariate setups. Discrete data analysis. (17)

Probability. Basic results. Conditional probability and Bayes theorem. Random variables-expectation and variance. Probability models for discrete and continuous variables. Computation of probability in various applied research. (15)

Basics of Statistical inference. Estimation and Hypothesis testing problems in special setups. Applications of statistical inference in applied research. (18)

References:

Goon, A. M., Gupta, M. K. and Dasgupta, B. - Fundamentals of Statistics, Vols 1 & 2

Goon, A. M., Gupta, M. K. and Dasgupta, B.- Outlines of Statistical Theory, Vols 1 & 2

Mood, A.M., Graybill, F.A. and Boes, D.C. (2007): Introduction to the Theory of Statistics, 3rd Edn. (Reprint), Tata McGraw-Hill Pub. Co. Ltd.

Ross, S. (2002): A First Course in Probability, Prentice Hall.

Rohatgi, V. K. and Saleh, A.K. Md. E. (2009): An Introduction to Probability and Statistics. 2nd Edn. (Reprint) John Wiley and Sons.

Snedecor G.W and Cochran W.G. (1967) Statistical Methods. Iowa State Univ. Press.

Casella, G. and Berger R.L. (2002).: Statistical Inference, 2nd ed. Thomson Learning.

A.Agresti (1984): Analysis of Ordinal Categorical Data