UNIVERSITY OF CALCUTTA

Notification No. CSR/ 15 /14

It is notified for the information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in exercise of his powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 10.04.2014, approved the Revised Course Structure and Syllabus for M.Sc. course of study in Statistics under this University as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2013-2014.

06.05.2014

SENATE HOUSE
KOLKATA-700073
The 6th May, 2014

(Prof. Basab Chaudhuri)

Registrar

UNIVERSITY OF CALCUTTA

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

2014

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 2013-14 will be same as the comprehensive and uniform regulations of Calcutta University (Notification CSR/ 55/ 09).

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 five 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. 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 26-40 marks, 41-50 marks and 51-75 marks will be of 1½ hours, 2 hours and 3 hours duration, respectively.

5. Each credit point is equivalent to 20 marks in the examinations.
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 3 elective papers in the 3rd semester and one module consisting of 3 special papers in the 4th semester. These are detailed in the syllabus of the respective semester.
10. Students will need to start their 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 = 500)

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 101 :	Analysis I	4 + 0	80 + 0
STAT 102 :	Probability I	4 + 0	80 + 0
STAT 103 :	Statistical Inference I	3 + 1	60 + 20
STAT 104 :	Linear Models	3 + 1	60 + 20
STAT 105 :	Optimization Techniques	2 + 1	40 + 20
STAT 106 :	C Programming	0 + 3	0 + 60
STAT 107 :	R Programming	0 + 3	0 + 60

Semester II : Total credits = 25 (Total Marks = 500)

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 201 :	Probability II	3 + 0	60 + 0
STAT 202 :	Multivariate Analysis	3 + 1	60 + 20
STAT 203 :	Statistical Inference II	4 + 1	80 + 20
STAT 204 :	Regression Analysis I	3 + 1	60 + 20
STAT 205 :	Design of Experiments	4 + 1	80 + 20
STAT 206 :	Sample Surveys	3 + 1	60 + 20

Semester III : Total credits = 25 (Total Marks = 500)

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 3 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. *Some of the elective papers are pre-requisites of certain special modules (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	60 + 20
STAT 302 :	Regression Analysis II	3 + 1	60 + 20
STAT 303 :	Stochastic Processes I and Time Series Analysis	4 + 1	80 + 20
STAT 304-306 :	Elective 1	3 + 1 or 4 + 0	60 + 20 or 80 + 0
STAT 307-309 :	Elective 2	3 + 1 or 4 + 0	60 + 20 or 80 + 0
STAT 310-312 :	Elective 3	3 + 1 or 4 + 0	60 + 20 or 80 + 0

Choice of Elective papers :

Elective 1 :*Any one from the following*

STAT 304 : Analysis II

STAT 305 : Demography

STAT 306 : Survival Analysis (*pre-requisite for Module 4*)

Elective 2 :*Any one from the following*

STAT 307 : Bayesian Methods

STAT 308 : Operations Research (*pre-requisite for Module 5*)

STAT 309 : Development Statistics

Elective 3 :*Any one from the following*

STAT 310 : Probability III (*pre-requisite for Module 1*)

STAT 311 : Advanced Sample Surveys

STAT 312 : Econometrics (*pre-requisite for Module 7*)

Semester IV : Total credits = 25 (Total Marks = 500)

In this semester, students are to select one special module from out of the modules offered in the particular year. Each module consists of three courses and a student selecting a module will have to take all the three courses. However, certain modules may have pre-requisite elective papers which the student must have taken in the 3rd semester to be eligible for that module.

Course No.	SUBJECT	CREDIT POINTS	MARKS
STAT 401 :	Applied Multivariate Analysis	3 + 1	60 + 20
STAT 402 :	Advanced Data Analytic Techniques	3 + 1	60 + 20
STAT403 :	Project Work	0 + 5	0 + 100
STAT 404/ 407/410/413/416/419/422 :	Special Paper 1	3 + 1 or 4 + 0	60 + 20 or 80 + 0
STAT 405/ 408/411/414/417/420/423 :	Special Paper 2	3 + 1 or 4 + 0	60 + 20 or 80 + 0
STAT 406/ 409/412/415/418/421/424 :	Special Paper 3	3 + 1 or 4 + 0	60 + 20 or 80 + 0

Choice of Special Modules: *Any one module from the following*

Module – 1 : Applied Probability and Stochastic Processes

Prerequisite Elective : Probability III

STAT 404 : Probability IV

STAT 405 : Stochastic Processes II

STAT 406 : Inference in Stochastic Processes

Module – 2 : Advanced Statistical Inference

STAT 407 : Advanced Parametric Inference

STAT 408 : Sequential and Semiparametric Methods

STAT 409 : Nonparametric Methods

Module – 3 : Advanced Design of Experiments

STAT 410 : Experimental Designs

STAT 411 : Fractional Factorial and Response Surface Designs

STAT 412 : Regression Designs

Module – 4 : Biostatistics

Prerequisite Elective : Survival Analysis

STAT 413 : Statistical Genetics

STAT 414 : Clinical Trials and Bioassay

STAT 415 : Epidemiology

Module – 5 : Industrial Statistics

Prerequisite Elective : Operations Research

STAT 416 : Statistical Quality Management

STAT 417 : Advanced Operations Research

STAT 418 : Reliability Theory

Module – 6 : Astrostatistics

STAT 419 : Astrophysics and related data sources

STAT 420 : Directional and Spatial Statistics

STAT 421 : Large scale Data Analysis

Module – 7 : Economic Statistics

Prerequisite Elective : Econometrics

STAT 422 : Advanced Time Series Analysis

STAT 423 : Advanced Econometrics

STAT 424 : Financial Econometrics

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. (6)
Bounded and unbounded subsets of the line, intervals, closed and open sets, characterizations, limit points, closures, interiors. Denseness. Compact sets. Heine-Borel, Bolzano-WeirstrassTheorems (statements). (8)
Functions: limits, continuity, uniform continuity, intermediate value theorem, differentiability; mean value theorem, Taylor's theorem (statement), extrema. (8)
Riemann integrals (3)
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
R.R.Goldberg : Methods of Real Analysis
J.C.Burkill : First Course of Mathematical Analysis
J.C.Burkill&H.Burkill : Second Course of Mathematical Analysis

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. (6)
Measures, finite, sigma-finite measures. Probability measures, properties. Independence of events, Borel-Cantelli lemmas. (4)
Measurable functions and properties, Generated sigma-fields.Induced measures.Compositions.Examples. (4)

Product sigma-fields, Borel sigma-field on Euclidean spaces. (3)
Extensions of measures, Caratheodory's theorem (statement). Lebesgue measure on R and R^k: 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, Monnotone Convergence Theorem, Dominated Convergence Theorem, Fatou's lemma. Change of variables. L_p spaces, Holder's and Minkowski's inequalities. Expectations, moments. Jensen's inequality. Generating functions.

(12)

Absolute continuity and singularity of measures. Radon-Nikodym Theorem (Statement). Discrete and absolutely continuous distributions. Lebesgue's differentiation theorem (statement), probability densities. (5)

References :

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

STAT 103 :Statistical Inference I (3+1)

Point Estimation (10)

Sufficiency and completeness, Exponential and Extended Exponential families. (5)
Rao-Blackwell and Lehmann-Scheffe Theorems, Minimum Variance Unbiased Estimators (5)

Testing of Hypotheses I (12)

Review of notions of nonrandomized and randomized tests, level, size, p-value, power function, Fundamental Neyman-Pearson lemma, UMP Tests (7)
Monotone Likelihood Ratio (3)
UMPU Tests: One parameter exponential family (2**)**

Sequential Analysis (**8**)

Sequential Tests, Wald's equation for ASN, SPRT and its properties-fundamental identity, OC and ASN, Optimality of SPRT (under usual approximation) (8)

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
B.K.Ghosh : Sequential Tests of Statistical Hypotheses
A. Wald : Sequential Analysis
N. Mukhopadhyay& B. M. de Silva: Sequential methods and their applications

STAT 104 :Linear Models (3+1)

Gauss Markov Model: Estimable function, error function, BLUE, Gauss Markov theorem. Correlated set-up, least squares estimate with restriction on parameters. (10)

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. (8)
Regression analysis (2)
Analysis of covariance. (4)

References :

H.Scheffe : The Analysis of Variance
S.R.Searle : Linear Models
G.A.F.Seber : Linear Regression Analysis
N.C. Giri : Analysis of Variance
D.D.Joshi : Linear Estimation & Design of Experiments

STAT 105 :Optimization Techniques (2+1)

Linear Programming – Simplex algorithm, Duality, Dual Simplex algorithm, Revised simplex Algorithm, Parametric programming, Transportation and Assignment problems. (16)
Search methods –-Fibonacci, Golden Section. (4)

References :

G.Hadley : Linear Programming
K.G.Murthy : Linear and Combinatorial Programming
S. N.S.Kambo : Mathematical Programming Techniques
S.S.Rao : Optimization – Theory and Applications
K.V.Mittal : Optimization Methods

STAT 106 :C Programming (0+3)

Overview of C language: Simple Syntax, loops, pointers, arrays, functions, files.
Algorithms and corresponding C-programs for

1. Sorting and Searching
2. Generation of Random Numbers and tests for randomness
3. Generation of samples from different theoretical distributions
4. Monte Carlo Integration
5. Acceptance-Rejection sampling
6. Importance Sampling
7. Missing data analysis

References :

B.W.Kernighan&D.M.Ritchie : The C Programming Language
D.E.Knuth : The Art of Computer Programming (Vol. 1 &2)

W.H.Press et.al : Numerical Recipes in C
N.Wirth : Algorithm and Data Structures

STAT 107 :R-Programming (0+3)

Overview; R help; help.search(), R mailing list, contributed documentation on CRAN.
Data types in R : numeric/character/logical; real/integer/complex, strings and the paste command, matrices, dataframes,lists, Creation of new variables, Creation of patterned variables, Saving workspace/history.
Graphics in R : the plot command, histogram, barplot, boxplot, points, lines, segments, arrows, inserting mathematical symbols in a plot,pie diagram, Customisation of plot-setting graphical parameters, adding text, saving to a file; Adding a legend.
Basic statistics using R : one and two sample t tests, Bartletts test for variance,F test for equality of variances, multi sample means, Nonparametric tests, Chi squared tests, Exact tests and confidence intervals, Checking assumptions, distribution fitting.
Vector matrix operations :Matrix operations such asaddition, subtraction, multiplication,; Linear equations and eigenvalues, matrix decomposition – LU, QR and SVD; matrix inverse, 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 no. generation &Simulations :rnorm, rchisq,rt, rbinometc; sample; set.seed, Monte Carlo techniques.
Programming in R.

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 measures. Fubini's theorem. (4)
Independence of random variables.Sums, variances, covariances.Kolmogorov's 0-1 law.Weak and strong laws of large numbers.Kolmogorov's inequality. (8)
Convergence in distribution. Scheffe's theorem, Slutsky's theorem.Law of Types.Asymptotic normality, Delta method. (6)
Integration of complex-valued functions, characteristic functions.Inversion and Continuity theorems.Central Limit Theorems. (6)
Lp-convergence of random variables, completeness and connections with other modes of convergence. (2)
Conditional expectations and properties (without proofs). (2)
Infinite product spaces, probability measures on infinite products: Kolmogorov's

consistency theorem (statement). (2)

References :

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

STAT 202 :Multivariate Analysis (3+1)

Non-central c^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. (6)
Distributions of partial and multiple correlation coefficients and regression coefficients, distribution of intraclass correlation coefficient. (4)
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, Multivariate Analysis of variance of one and two way classified data (only LR test). (9)

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
M.S.Srivastava&C.G.Khatri : Introduction to Multivariate Statistics
R.J.Muirhead : Aspects of Multivariate Statistical Theory

STAT 203 :Statistical Inference II (4+1)

Testing of Hypotheses II & Confidence Set Estimation (14)
Generalized Neyman-Pearson Lemma. (1)
Locally best tests. (2)
Similar tests, Neyman structure, UMPU tests for composite hypotheses. (6)
Confidence sets based on pivot, relation with hypothesis testing, Optimum parametric confidence intervals . (5)

Asymptotic Inference (12)
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. (5)

Bayesian Analysis (**14**)

Elements of decision theory: Preliminary ideas of decision rules, loss and risk [2]

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. (7)

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

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)

Discontinuous explanatory variables – Dummy variables, piecewise regression, splines. (4)

Detection of outliers and influential observations : residuals and leverages, DFBETA, DFFIT and Cook's Distance. (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 Practiceof Econometrics (2nd ed.)
T.P. Ryan : Modern Regression Methods (2nd ed.)
J.O.Rawlings, S.G.Pantula& : Applied Regression Analysis: A Research Tool

&D.A.Dickey
S. Chatterjee, A.S. Hadi, : Regression Analysis by Example

STAT 205 :Design of Experiments (4+1)

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

(10)Intrablock analysis of BIB, Lattice and PBIB designs, Row column designs, Youden Square designs, Recovery of interblock information in BIB designs. Missing plot technique. (10)

Construction of mutually orthogonal Latin Squares (MOLS); Construction of BIB designs through MOLS and Bose's fundamental method of differences. (8)

Factorial designs: Analysis, Confounding and balancing in Symmetric Factorials. (10)

Response Surface Designs – First order model (2)

References :

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

STAT 206 :Sample Surveys (3+1)

Probability sampling from a finite population – Notions of sampling design, sampling scheme, inclusion probabilites, 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.(9)

Stratified sampling – Allocation problem and construction of strata. (3)

Ratio, Product, Difference and Regression estimators. Unbiased Ratio estimators – Probability proportional to aggregate size sampling, Hartley – Ross estimator in simple random sampling. (5)

Sampling and sub-sampling of clusters. Two-stage sampling with equal/unequal number of second stage units and simple random sampling without replacement / unequal probability sampling with replacement at first stage, Ratio estimation in two-stage sampling. (5)

Doube sampling for stratification.Double sampling ratio and regression estimators.Sampling on successive occasions. (4)

References :

W.G.Cochran	:	Sampling Techniques, 3rd ed.
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.

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 :Stochastic Processes I and Time Series Analysis (4+1)

Stochastic Processes I (25)
Introduction, Poisson process (3)
Renewal Theory: renewal processes, renewal function, elementary renewal theorem, applications, Blackwell's theorem and key renewal theorem (statements), applications, alternating renewal processes, applications to limiting excess and age. (7)
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. (7)
Examples: birth-and-death processes, branching processes. (2)
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. (6)

Time Series Analysis (15)
Stationary time series. Autocorrelation and partial autocorrelation functions. (6)
Forecasting techniques : Box-Jenkins Model – basic ideas. (5)
Volatility : ARCH, GARCH models – basic ideas. (2)
Smoothing Techniques – exponential and Holt-Winters methods. (2)

References :

S.Karlin&H.M.Taylor : A First Course in Stochastic Process, Vol-1
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
A.Pankratz : Forecasting with Univariate Box-Jenkins Model
G.Janacek and L.Swift : Time Series –Forecasting,Simulation, Applications

Elective Papers

Group - 1

STAT 304 :Analysis II (4+0)

Metric spaces: open, closed, compact sets, closures, interiors, dense sets, sequences and limits, subsequences, completeness, connectedness. Functions and continuity, Banach's Fixed Point Theorem (15)
Vector spaces, subspaces, linear transformations, matrices, eigenvalues and eigenvectors, Cayley-Hamilton theorem, quadratic forms, inner product spaces, orthonormal basis, Hilbert spaces (10)
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. (15)

References :

T.M.Apostol : Mathematical Analysis
W.Rudin : Principles of Mathematical Analysis
R.R.Goldberg : Methods of Real Analysis
P Bhimasankaram&A R Rao : Linear Algebra
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 305 :Demography (3+1)

Definition of concepts: Life and Death, Death Rates- age, space and cause specific. Adjusted death rates, Natality: Birth rates- age-sex adjusted, Quality Adjusted Life. Migration-related measures. (8)
Life tables: Distribution of life table functions and their estimates. Multiple Decrement tables. (6)
Growth curve models, Population Estimation and Projection, Methods for Population projection.Stable and quasi stable population, intrinsic growth rate. (6)

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 ed.)
C.L.Chiang : Introduction to Stochastic Processes in Biostatistics
P.R.Cox : Demography
H.S.Shryock et.al. : The Methods and Materials of Demography
N.Keyfitz and N. Caswell : Applied Mathematical Demography

STAT 306 :Survival Analysis (3+1)

Introduction.Basic functions and Models.Censoring and Truncation. (5)
Parametric univariateestimation : 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 and M.Klein: Survival Analysis – A Self-Learning Text

Group 2

STAT 307 :Bayesian Methods (3+1)

Details on Conjugate priors, and posteriors, Bayesian model selection. (8)
Generalized linear models and categorical data, longitudinal models (10)
Theoretical aspects of MCMC (4)
Bayesian Econometrics and Spatial Data Analysis. (8)

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 308 : Operations Research (3+1)

Definition and Scope of Operations Research (2)
Decision-making under uncertainty and risk, use of different criteria, sensitivity analysis. (2)
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. Non-zero-sum game (4)
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, (7)
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. (4)
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 (6)

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 309 :Development Statistics (3+1)

Concept of economic development – role of statistics.National and international statistical systems. (3)
National accounts – estimation of national and state incomes and their components.(4)
Projection of populations. (2)
Distribution of income – measurement of poverty and inequality. (8)

Measures of unemployment. (4)
Development indices. (4)
Other indicators of development (5)
(*includes* agriculture – crop-forecasting and estimation, crop insurance, procurement and buffer stock management; water resources management; industrial growth; foreign trade and balance of payments; planning and allocation of resources; evaluation of family welfare programmes)

References :

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
World Bank : Yearly Reports

Group 3

STAT 310 :Probability III (4+0)

Uniform integrability, applications. (6)
Conditional expectations and their properties (with proofs).Regular conditional probabilities and distributions. (8)
Discrete parameter martingales: filtrations, martingales, sub-, super-, reversed martingales, examples, maximal inequality, upcrossings inequality, convergence theorems, closability, stopping times, optional sampling. Applications. (20)
Stationary processes, second-order processes, spectral distribution. (6)

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

STAT 311 :Advanced Sample Surveys (3+1)

Unified theory of finite population sampling.Sampling design, sampling scheme.Hanurav's unit drawing algorithm, Data and estimators – linear and linear unbiased estimators of population total, Horvitz-Thompson estimator, Generalized Difference and Generalized Regression estimators.Issues in non-negative variance estimation.πPS sampling schemes, Rao-Hartley-Cochran strategy. (10)

Non-existence of UMVUE.Existence / Non-existence of UMVLUE of a population total.Concepts of sufficiency and likelihood in survey sampling.Rao-Blackwell theorem and its applications.Murthy's unordering principle. (6)
Inference under super-population models.Optimal design unbiased strategies and optimal linear model unbiased prediction under simple regression models. (6)
Estimation for domains – issues in small domain estimation. (4)
Randomized response techniques.The Warner model and the unrelated question models. (4)

References ;

C.M.Cassel, C.E.Sarndal.&J.H.Wretman :Foundations of Inference in survey Sampling
A.Chaudhuri&R.Mukerjee :Randomized Response –theory andtechniques
A.Chaudhuri&J.W.E.Vos : United Theory and Strategies of Survey Sampling
A.S.Hedayat&B.K.Sinha : Design and Inference in Finite Population Sampling
P.Mukhopadhyay : Inferential Problems in Survey Sampling
C.E.Sarndal, B.Swensson&J.Wretman : Model assisted Survey Sampling

STAT 312 :Econometrics (3+1)

Single-equation linear model – censored data, errors-in-variables, lagged variables. (7)
Simultaneous Equations – identification & estimation. SUR models (12)
Analysis of Panel Data (6)
Nonparametric and semiparametric methods in econometrics (5)

References :

J.Johnston : Econometric Methods
G.G.Judge, et.al. : The Theory and Practice of Econometrics (2nd ed.)
W.Greene : Econometric Analysis
E.Malinvaud : Statistical Methods in Econometrics
A.Pagan&A.Ullah : Non-parametric Econometrics
B.M. Baltagi : Econometric Analysis of Panel Data

Semester IV

STAT 401 :Applied Multivariate Analysis (3+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. Tests associated with discriminant function, Probabilities of misclassification

and their estimation. Classification of several populations.Fisher's method for discriminating among several populations. (9)
Principal Component Analysis: Population and sample Principal components and their uses. Plotting techniques, Large sample inferences. (4)
Factor Analysis: The orthogonal factor model, Estimation of factor loading, Factor rotation, Estimation of Factor scores, Interpretation of Factor Analysis. (6)
Canonical Correlation: Population and sample canonical variables and canonical correlations and their interpretations. Plotting techniques, Large sample inferences. (5)

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

STAT 402 :Advanced Data Analytic Techniques (3+1)

Resampling Techniques (**10**)
Introduction to Jackknife and Bootstrap-methods for estimating bias, standard error and distribution function based on iid random variables, standard examples (8)
Bootstrap confidence intervals (2)

Missing data analysis (10)
Informative or non-informative missingness; complete case / available case estimation , Imputation, EM & MCEM algorithms and data augmentation techniques.Standard error estimation. (10)

Longitudinal data analysis (10)
Longitudinal regression : Cohort vs longitudinal effect, Weighted least-squares, ML and REML techniques. Marginal, subject specific and transition models, GEE. (10)

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. Diggleet. al. : Analysis of Longitudinal Data (2nd ed).

STAT 403 : Project Work (0+5)

Students to do this on their own.

Special Papers

MODULE – 1 : APPLIED PROBABILITY AND STOCHASTIC PROCESSES

Prerequisite Elective: Probability III

STAT 404 :Probability IV (4+0)

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:

David Freedman : Brownian motion and diffusions
P. Billingsley : Convergence ofprobabilitymeasures.
K.R.Parthsarathy : Probabilitymeasures on metric spaces.
R.L.Schilling&L.Partzsch : Brownian motion.
De Gruyter : An introduction to stochastic processes
P.Mörters&Y.Peres : Brownian motion.

STAT 405 :Stochastic Processes II (4+0)

Markov processes, semigroups and generators. Strong Markov, Feller processes. (12)
Infinitely divisible distributions, Levy-Khintchine representation. Levy processes, stable distributions and processes. (10)
Continuous-parameter martingales, sub-, super-martingales, path properties, examples. (12)
Point processes. Poisson and related random measures. (6)

References:

S N Ethier& T G Kurtz : Markov Processes: Characterization and Convergence.
W Feller : An Intro.to Probability Theory and Its Applications, Vol. II.

S Karlin and R J Taylor : A First Course in Stochastic Processes
S Karlin and R J Taylor : A Second Course in Stochastic Processes

STAT 406 :Inference in Stochastic Processes (4+0)

Parametric estimation and testing problems in Branching processes, Markov chains in discrete and continuous time, Point processes. (22)
Introduction to stochastic calculus with respect to Brownian motion, diffusions. (12)
Parametric inference in diffusions. (6)

References:

I.V.Basawa&B.L.S.PrakasaRao : Statistical Inference for StochasticProcesses
B.Øksendal : Stochastic differential equations: An introduction withapplications
Yu.A.Kutoyants : Parameter estimation for stochastic processes
R.L.Schilling&L.Partzsch :Brownian motion. An introduction to stochastic processes
I.Karatzas&S.E.Shreve : Brownian motion and stochastic calculus, 2nd ed.

MODULE – 2 :ADVANCED STATISTICAL INFERENCE

STAT 407 : Advanced Parametric Inference (4+0)

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. (13)
Improved estimation of mean and dispersion under the normal set up. (5)
Behrens-Fisher problem and its generalisation.Scheffe's solution in the univariate case and its multivariate extension.Welch's approach.Banerjee's approach. (6)
Multiple Hypothesis Testing (8)
Hypothesis testing problem under order restricted problems (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 408 :Sequential and Semiparametric Methods (3+1)

Sequential Methods (20)
Brownian Approximation and Truncated Tests, Tests with curved stopping boundaries, Repeated significance tests, Fixed width interval estimation, Group sequential approach, Partial Sequential tests

Semiparametric Models and their Analyses (10)
Single-Index-Models.Generalised Partial Linear Models.Generalized Additive Models. Different types of likelihood functions.

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 409 : Nonparametric Methods (3+1)

U-Statistics	(5)
Linear Rank Statistic and its asymptotic distribution under null and different local alternatives.	(8)
Consistency and Asymptotic Relative efficiency.Optimality of tests.	(4)
Bivariate Sign Test	(2)
Hodges-Lehmann Esimators and their properties	(3)
M, L and R – estimators, Projection Principle, Density Estimation	(3)
Influence function	(2)
Simple Regression under nonparametric set up	(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

MODULE – 3 :ADVANCED DESIGN OF EXPERIMENTS

STAT 410 :Experimental Designs (3+1)

PBIB designs	(8)
Optimum Experimental Designs	(8)
Weighing Designs	(8)
Optimum Covariate designs	(6)

STAT 411 :Fractional Factorial and Response Surface Designs (3+1)

Fractional factorial Designs	(10)
Response Surface Designs	(20)

STAT 412 :Regression Designs (3+1)

Optimum Regression Designs	(15)
Mixture Experiments	(15)

References:

R.C.Bose&T.Shimamoto	:	Classification and analysis of partially balanced incomplete block designs. J.A.S.A.47, 151-184, 1952
D.Raghavarao	:	Construction and combinatorial problems in design of experiments
A.Dey & R.Mukerjee	:	Fractional Factorial Plans
J.Kiefer	:	Optimum experimental designs: J.R.S.S.(B), 21, 272-304, 1959
K.R.Shah&B.K.Sinha	:	Theory of optimal designs
E.P.Liski, N.K.Mandal, K.R.Shah &B.K.Sinha	:	Topics in optimal design
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

MODULE – 4 :BIOSTATISTICS

Prerequisite Elective: Survival Analysis

STAT 413 :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 analysis	(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 414 :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 415 :Epidemiology (3+1)

Measures of Disease frequency and Association. (6)

Study designs: Ecological, Cross-sectional, Cohort, Case-Control and its variants. (6)
Sensitivity and Specificity.Confounding. (5)
The analysis of cohort and case-control studies.Matched data. (5)
Intervention studies: Clinical Trials. (8)

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

MODULE – 5 :INDUSTRIAL STATISTICS

Prerequisite Elective: Operations Research

STAT 416 :Statistical Quality Management (3+1)

Moving average and exponentially weighted moving average charts. Cu-sum charts using V-masks and decision intervals. Economic design of $\overline{X}$ - chart. (7)
Multivariate Control Charts (5)
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 (3)
QM System and ISO 9001 – brief exposition. (2)
Basic concepts of 6σ - DMAIC approach and the metrics used. (4)

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 417 : Advanced Operations Research (3+1)

M/G/1 queue and Pollazcek-Khinchine result. Steady-state solutions of M/Ek/1 and Ek/M/1 queues. (4)
Traveling salesman problem - Branch and Bound method, Simulated annealing. (4)
Non-linear programming – multivariate optimization with inequality constraints. Kuhn-Tucker conditions. Convex programming, Quadratic Programming – Wolfe's algorithm. (10)
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)
Dynamic programming and its applications in solving various OR problems. (6)

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 418 :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 and 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

MODULE – 6 : ASTROSTATISTICS

STAT 419 : 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, Luminosity effects, Absolute and apparent magnitude, Mass luminousity relation, Spectroscopic parallax.(5)
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-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

STAT 420 :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. (4)
Statistical inference in one and several von Mises populations. (4)
Circular Goodness-of-Fit tests. (2)
Theory of Spatial Statistics- planar statistics-nearest neighbor. (2)
Planar regression. (5)
Spatial autocorrelation. (4)
Spatial Distribution of galaxies. (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

STAT 421 :Large scale Data Analysis (3+1)

Generalization of Linear Regression- Ridge Regression, Partial least squares, LASSO and Least angle regression, Principal Components Regression. (8)
Tree based methods- Classification and Regression Trees (CART), Patient rule induction method (PRIM), Multivariate Adaptive Regression Splines (MARS). (7)
Generalization of Linear Discriminant Analysis- Flexible Discriminant Analysis, Penalized Discriminant Analysis, Mixture Discriminant Analysis. (6)
Generalization of Principal Component Analysis- Kernel Principal Components, Sparse Principal Component Analysis, Independent Component Analysis (ICA). Multidimensional Scaling. (7)
Applications of above methods in Astronomical Data. (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

MODULE – 7 :ECONOMIC STATISTICS

Prerequisite Elective: Econometrics

STAT 422 :Advanced Time Series Analysis (3+1)

Box-Jenkins Models – identification, estimation, diagnostic checking, forecasting. (7)
ARCH and GARCH models and their variants – identification, estimation, diagnostic checking, forecasting. (10)
State Space Models. (4)
Testing for Unit Roots – Dickey-Fuller, Augmented Dickey-Fuller and other tests. (3)
Spectral Analysis. (6)

References :

G.E.P.Box, G.M.Jenkins &G.C.Reinsel	:	Time Series Analysis – Forecasting and Control
P.Brockwell&R.A.Davis	:	Time Series – Theory and Methods
W.A.Fuller	:	Introduction to Statistical Time Series (2^{nd}ed.)
G.Janacek&L.Swift	:	Time Series, Forecasting, Simulations & Applications
G.C.Reinsel	:	Elements of Multivariate Time Series Analysis

STAT 423 :Advanced Econometrics (3+1)

Economic models – applications of single and simultaneous equations techniques. Demand and Production Function Analyses. (8)
Bayesian Econometrics. (8)
Use of multivariate time series models. Applications of VAR and VARMA models – Granger causality, Exogeneity testing. (4)
Ideas of Long-range Dependence.Fractional Differencing. (5)
Cointegration. (5)

References :

M.D.Intrilligator,R.G.Bodkin: &C.Hsiao — Econometric Models, Techniques and Applications
H.Wold&L.Jureen : Demand Analysis – a study in econometrics
P.Sankhayan : An Intro.to the Economics of Agricultural Production
G.S.Maddala& I.M. Kim : Unit Roots, Cointegration, and Structural Change
A.Zellner : Bayesian Econometrics

STAT 424 :Financial Econometrics (3+1)

Risk-free and risky assets.Contracts and options.Continuous compounding, present valuation, risk, risk-neutral valuation. (6)
Self-financing portfolios in finite markets.Replication, arbitrage, market completeness and existence.Hedging.Harrison-Pliska arbitrage theorem.Capital assets pricing models. (8)
Derivative pricing models.Option Pricing.Cox-Ross-Rubinstein Binomial and Black-Scholes models. (8)
Portfolio management, Value-at-risk. (8)

References :

A. N. Shiryaev : Essentials of stochastic finance: facts, models, theory
S. Ross : An elementary introduction to mathematical finance
J.Y.Campbell,A.W.Lo&C.MacKinlay : The Econometrics of Financial Markets
M.Baxter&A.Rennie: Financial Calculus: An Introduction to DerivativePricing
M. Ross : Intro. to Mathematical Finance: Options and OtherTopics
N.H.Bingham&R.Kiesel : Risk-Neutral Value Pricing & Hedging of Financial Derivatives
V.S.Bawa, S.J.Brown, R.W.Klein:Estimation Risk and Optimal Portfolio Choice