M.Sc. (STATISTICS): COURSE STRUCTURE

(with effect from 2016 ADMISSION ONWARDS)

A. Preamble:

The University Grants Commission, New Delhi has directed all Universities in the Country to implement the Choice Based Credit System (CBCS Semester Scheme)in both the Undergraduate and Post-Graduate programmes. The Higher Education Council, Government of Karnataka also considered the implementation of CBCS. Mangalore University considered feasibility of CBCS at several levels and through meeting of its statutory bodies and finally directed all the P.G. Board of Studies to frame the new syllabus for the P.G. Programmes as per the new regulations governing the Choice Based Credit System for the Two Year (Four Semester) Post-Graduate Programmes. Accordingly the internal members of P.G. Board of Studies in Statistics discussed in length, on CBCS – PG Scheme and prepared a draft syllabus. The syllabus is placed before the P.G. Board of Studies. The P.G. Board of Studies in Statistics thoroughly discussed, modified and finalised the draft syllabus.

The present M.Sc. programme under CBCS-PG Scheme has total credits 90 (14 Hard Core Courses of 54 credits + 10 Soft Core Courses with 30 credits and two open elective with 6 credits). Apart from teaching core Statistics subjects, the students are also trained to handle real life problems through the practical classes. As a part of the course the students are taught programming in Excel and R-Software.

B. Course pattern for M.Sc.(Statistics) Programme from 2016-17.

Semester	Hard Core			Soft Core			Open Elective			Project	Total
	No. of Papers	Credits	Total Credits	No. of Papers	Credits	Total Credits	No. of Papers	Credits	Total Credits	Credits	Total Credits
I	4 Theory 1 Practical	4x4=16 1x3=3	19	1 Practical	1x3=3	3	-	-	-	-	22
II	3 Theory 1 Practical	3x4=12 1x3=3	15	1 Theory 1 Practical	1x3=3 1x3=3	6	1	3	3	-	24
III	2 Theory 1 Practical	2x4=8 1x3=3	11	2 theory 1 Practical	2x3=6 1x3=3	9	1	3	3	-	23
IV	1 theory	1x4=4	4	3 Theory 1 Practical	3x3=9 1x3=3	12	-	-	-	5	21
			49			30			6	5	90

C. Scheme of Internal Assessment Evaluation:

The scheme of evaluation for internal assessment marks shall be as follows:

(i) Two tests each of 2 hrs. duration: 10x2= 20 marks

(ii) Seminar/Assignment/Viva/ Multiple Choice Test etc. .: = 10 marks

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Total: 30 marks

D. Question Paper Pattern:

The pattern of question papers in theory examinations shall be as follows:

1. There shall be totally 8 questions of which the Q. No. 1 is compulsory.

   Students have to answer any 4 questions from the remaining 7 questions.

2. Q.No.1 will contain two parts. Part 1 and Part 2. Part 1 will contains 10 multiple choice questions of one mark each. Part 2 contains 6 sub questions of 3 marks each. Students will have to answer all questions from Part 1 and any four sub questions from Part 2.

3. Q.No.2 to Q.No.8 will be of long answer type, each carrying 12 marks.

   The distribution of marks will be as follows:

Q.1 - Part 1 : 10 x 1 = 10

Part 2 : 4 x 3 = 12

Any four questions out of remaining 7 12 x 4 = 48

Total: **70**

Hard Core Courses (4 **Credit each**)

First Semester M.Sc., Statistics

Code	**Course**
STH401	Real Analyses
STH402	Matrix Theory and R Programming
STH403	Probability Theory
STH404	Theory of Sampling
STP405	Practical I - Based on STH404
STP406	Practical II-(R-Programming &Excel)

Second Semester M.Sc., Statistics

STH452	Distribution Theory
STH453	Theory of Point Estimation
STH454	Econometrics
STS455:	Actuarial Statistics
STP456:	Practical III: Based on STH454-Econometrics
STP 457:	Practical IV: Based on STH 452, STH453 &STS455

Third Semester M.Sc., Statistics

STE501:	STATISTICAL TESTING IN DATA ANLYSIS
STH502:	TESTING OF HYPOTHESIS
STH503:	STOCHASTIC PROCESSES
STS 504:	SOFT COURSE
STS 505:	SOFT COURSE
STP506:	PRACTICALS V (BASED ON STH 502 & STS 504)
STP507:	PRACTICAL VI –(BASED ON STH 503 & STS505)

Fourth Semester M.Sc., Statistics

STH551:	Design and Analysis of Experiments
STS 552:	SOFT COURSE
STS 553 :	SOFT COURSE
STS 554 :	SOFT COURSE
STP555 :	PRACTICAL VII-Based on all Theory papers:STH551, STS552, STS553 & STS554

STP556 : PROJECT WORK

Soft Core Courses (3 Credits each)

Code	**Course**
STP406	Practical II – Programming in R and Excel
STS455	Actuarial Statistics
STP457	Practical IV: Based on Theory Papers : (ST STH452, STH 453 & one soft course)
STS504	Multivariate Analysis
STS505	Time Series Analysis
STS507	Survival Analysis
STP 508	Practical VI: Based on Theory Papers(STH503 & one soft course offered)
STS552	Operation Research
STS553	Statistical Finance
STS554	Financial Time Series
STS557	Data mining Techniques
STS558	Nonparametric Regression
STS559	Data Analytics
STS560	Financial Time series
STS561	Theory of Big data
STS562	Structural Equation Model
STS563	Risk and Ruin Models in Insurance
STS564	Official Statistics
STP565	Practical VII -Based on Theory Paper on (STH551, and three soft core courses offered)
STS566	Bayesian Inference

Open Elective:

STE451	Statistical Methods
STE501	Statistical testing in Data Analysis

M.Sc. STATISTICS

(CBCS Semester Scheme)

Scheme of Teaching and Examination

(As per the University Guidelines)

I Semester

Course Code	Title of the Paper	Hard Core(HC)/ Soft Core(SC)	Credits	Examination Duration	Internal Assessment Marks	End Semester Examination Marks	Total Marks
STH401	REAL ANALYSIS	HC	4	3 hrs.	30	70	100
STH402	MATRIX THEORY AND R-PROGRAMME	HC	4	3 hrs.	30	70	100
STH403	PROBABILITY THEORY	HC	4	3 hrs.	30	70	100
STH404	THEORY OF SAMPLING	HC	4	3 hrs.	30	70	100
STP405	PRACTICAL- I (BASED ON STH404 THEORY OF SAMPLING)	HC	3	3 hrs.	30	70	100
STP406	PRACTICAL- II USING EXCEL AND R-PROGRAMMING	SC	3	3 hrs.	30	70	100

II Semester

STE451	STATISTICAL METHODS	OE	3	3 hrs.	30	70	100
STH452	DISTRIBUTION THEORY	HC	4	3 hrs.	30	70	100
STH453	THEORY OF POINT ESTIMATION	HC	4	3 hrs.	30	70	100
STH454	ECONOMETRICS	HC	4	3 hrs.	30	70	100
STS455	Soft Course	SC	3	3 hrs.	30	70	100
STP456	PRACTICAL -III BASED ON STH454 ECONOMETRICS	HC	3	3 hrs.	30	70	100
STP457	PRACTICALS-IV BASED ON STH452 STH453 & One soft course	SC	3	3 hrs.	30	70	100

III Semester

STE501	STATISTICAL TESTING IN DATA ANLYSIS	OE	3	3 hrs.	30	70	100
STH502	TESTING OF HYPOTHESIS	HC	4	3 hrs.	30	70	100
STH503	STOCHASTIC PROCESSES	HC	4	3 hrs.	30	70	100
STS 504	SOFT COURSE	SC	3	3 hrs.	30	70	100
STS 505	SOFT COURSE	SC	3	3 hrs.	30	70	100
STP506	PRACTICALS V (BASED ON STH 502 & One soft course)	HC	3	3 hrs.	30	70	100
STP507	PRACTICAL VI – (BASED ON STH 503 & one soft course)	SC	3	3 hrs.	30	70	100

IV Semester

STH551	DESIGN AND ANALYSIS OF EXPERIMENTS	HC	4	3 hrs.	30	70	100
STS 552	SOFT COURSE	SC	3	3 hrs.	30	70	100
STS 553	SOFT COURSE	SC	3	3 hrs.	30	70	100
STS 554	SOFT COURSE	SC	3	3 hrs.	30	70	100
STP555	PRACTICAL VII- Based on all Theory papers:STH551, STS552, STS553 & STS554	SC	3	3 hrs.	30	70	100
STP556	PROJECT WORK	HC	5	-	30	70	100

(ISMAIL B.)
Chairman, P.G.B.O.S. in Statistics

Detailed Syllabus

Hard Core	STH401: REAL ANALYSIS	No. of hrs./week:4

Unit-I

Introduction to n-dimensional Euclidean space; open and closed sets, countable set, properties of countable set, Bolzano-Weirstrass theorem (statement only), Heine-Borel theorem (statement only), compact set. (9 hrs)

Unit-II Sequences and their convergence- bounded sequences, monotone sequences, limit superior and limit inferior, Cauchy sequences. Series- convergence and divergence, tests for convergence. (10 hrs)

Unit-III

Real valued functions, continuous functions, monotonic functions, discontinuities of real valued functions, uniform continuity, sequences and series of functions, uniform convergence- uniform convergence of sequences, definition and examples, Cauchy criterion for uniform convergence, uniform convergence and integration, uniform convergence and differentiation, uniform convergence of infinite series of function, Weirstrass M-test, Dirichlet's test. Power series-definition, radius of convergence and examples. (12 hrs)

Unit –IV

The Reimann Stieltjes' integration, properties. Integration by parts, change of variables, step functions as integrators, monotonically increasing integrators. (09 hrs)

Unit-V Improper integrals – Beta and gamma integrals. Extrema of real valued functions-one variable & several variables, stationary point, saddle point, local and global extrema, extremum problems with restrictions-Lagrange's method. (10 hrs)

References:

1. Apostol, T.M. (1996) Mathematical Analysis, Narosa Publshing House, New Delhi, Second Edition.
2. Khuri, A.T. (1993) Advanced Calculus with Applications in Statistics, John Wiley & Sons, Inc.,
3. Malik S.C.and Savitha Arora (1993): Mathematical Analysis, Wiley Eastern
4. Robert G. Bartle (1975): The elements of Real Analysis, 2 nd Ed., John Wiley & Sons.
5. W. Rudin (1976): Principles of Mathematical Analysis, 3rd Ed., McGraw-Hill, New York.

6. Shanti Narayan (1991) A text of book of matrices, S. Chand & Company, New Delhi.

Hard Core	STH402: MATRIX THEORY AND R- PROGRAMMING	No. of Credits:4

Matrix Theory

Unit 1: Vector spaces, linear dependence and independence; basis and dimension of a vector space. Orthonormal basis and orthogonal projections. Gram-Schmidt orthogonalization process. (8 hrs)

Unit 2: Types of matrices, determinant, row and column spaces of a matrix, rank and inverse of a matrix. Null space and nullity; partitioned matrices; Kronecker product. Generalised inverse, Moore- Penrose Inverse. Linear equation-homogenous and non-homogenous systems, solution spaces. (12 hours)

Unit 3: Characteristic roots and vectors, Cayley-Hamilton theorem, algebraic and geometric multiplicity of characteristic roots. Determinant, rank and trace of a matrix in terms of characteristic roots. Real quadratic forms, classification of quadratic forms, reduction of quadratic forms, index and signature. Sylvester's law of Inertia. Vector and matrix differentiation. (12 hours)

R- Programming

Unit 4

Introduction to R. Storing data. Starting R, setting directories. Regular expressions in R and their evaluation. Vectors and matrix. Operations with matrix, submatrices, subsetting, missing values. Subscripting, rbind() and cbind(). Functions, Data frames, names, attach, detach, expanding data frames. Libraries of R. Script editor in R. Syntax in R programming. Using logical expressions. If functions. Loops in R – for, while, repeat. (10 hrs)

Unit 5

Handling data files: Reading data from text file, from excel file and web pages. Scan() function, Saving output in a file, printing outputs and files. Graphics, designing graphs. User defined function programs. Packages, loading packages.

Functions for statistical distributions, some statistical tools in R. Some program examples using these features. Debugging. (8 hrs)

Reference:

1 Hadley, G.(1987): Linear Algebra, Narosa
2 Rao, C.R. (1973): Linear Statistical Inference and its Applications, second edition, Wiley.
3 Searle S.R.(1982): Matrix Algebra Useful for Statistics, John Wiley& Sons.
4 John Verzani(2005), “Using R for Introductory Statistics”, Chapman & Hall/CRC
5 Alain F. Zuur et. al. (2009) “A Beginner's Guide to R. Use R! Series” Springer.
6 Phil Spector (2008), “Data Manipulation with R. Use R! Series”, Springer.
7 A. Ramachandra Rao, and P. Bhimasankaram (2000), “Linear Algebra”, Hindustan Book Agency.

Hard Core	STH403: PROBABILITY THEORY	No. of credits: 4

Unit-I

Classes of sets, sequence of sets, limit superior and limit inferior of a sequence of sets. Fields, sigma-fields, minimal sigma-field, Borel sigma-field in R. (10 hrs)

Unit-II

Measure, probability measure, properties of probability measure, Independence. General distribution functions, Lebesgue and Lebesgue-Steiltjes measures on R. Measurable functions, random variables, induced probability measure and distribution function and properties. Jordan decomposition theorem (without proof) and mixture of probability distributions (10 hrs)

Unit-III

Integration with respect to a measurable function. Expectation of a random variable. Monotone convergence theorem, Fatou's lemma, Dominated convergence theorem. Sequence of random variables. Convergence in distribution, convergence in probability. Properties and examples. (10 hrs)

Unit-IV

Almost sure convergence, convergence in r^{th} mean. Borel-Cantelli Lemma. Khintchine and Chebychev's weak law of large numbers. Kolmogorov's generalised weak law of large numbers, Kolmogorov's strong law of large numbers for sequence of independent and sequence of iid random variables. (10 hrs)

Unit-V

Characteristic functions: Definition and simple properties, inversion formula (density function), uniqueness theorem, Levy's continuity theorem.

Central limit theorem, Lindeberg-Levy and Liapounov central limit theorems. Statement of Lindeberg-Feller central limit theorem. Applications of these theorems.

(10 hrs)

References:

1) Bhat B.R. (1999):Modem Probability Theory, 3rd Ed., New Age Publishers.
2) Basu, A.K. (1999): Measure Theory and Probability, Prentice-Hall of India.
3) Chow Y.S. and Teicher H. (1979): Probability Theory, Narosa Publishing House.
4) Kingman JFC and Taylor S.J. (1966): Introduction to Measure and Probability, Cambridge University Press.
5) Laha R.G. and Rohatgi V.K. (1979): Probability Theory, John Wiley.
6) Robert B.Ash (2000): Probability and Measure Theory, A Harcourt Science and Technology Company
7) Rohatgi V.K. and A.K.E. Saleh (2001): Introduction to Probability and Statistics, John Wiley & Sons.
8) David Stirzaker (1994) “Elementary Probability”, Cambridge University Press.
9) Geoffrey Grimmett and Dominic Welsh (2003) “Probability- An Introduction” Oxford Science Publishers.
10) Kai Lai Chung (2001) A Course in Probability Theory, Academic Press.

Hard Core	STH404: THEORY OF SAMPLING	No. of Credits:4

Unit-I

Basic Concepts: Sampling design, sampling scheme, sampling strategy, interpenetrating subsampling.

Probability Proportion to Size with Replacement (PPSWR) Sampling: Selection of PPSWR sample. Estimation of population mean, total and their sampling variances – Hansen-Hurwitz strategy. Estimation of sampling variance. Comparison with SRSWR, Estimation of Gain due to PPSWR sampling. (12 hrs)

Unit-II

Varying Probability Without Replacement (PPSWOR) Sampling: Some properties of sampling design, Horwitz-Thompson estimator, sampling variance of population total and its unbiased estimator. Sen-Midzuno Sampling Scheme, Des-Raj's Ordered estimator (general case), Murthy's unordering principle (sample of size two), Rao-Hartley-Cochran sampling strategy. (10 hrs)

Unit-III

Single stage cluster sampling: Concepts, estimation of efficiency of cluster sampling, clusters of varying sizes.

Two stage sampling: Notions, estimation of population total and its variance, when SRSWR is used at first stage and SRSWOR at the second stage, SRSWOR at both stages and PPSWR at the first stage and SRSWOR at the second stage. Efficiency of two-stage sampling relative to cluster and SRS sampling. (10 hrs)

Unit-IV

Ratio and regression estimators based on SRSWOR, method of sampling, bias and mean square errors, comparison with mean per unit estimator.

Two phase sampling: notion, double sampling for ratio estimation, double sampling for regression estimation. (10 hrs)

Unit-V

Randomized response techniques: Warner's model, related and unrelated questionnaire methods, Nonsampling errors.

Statistics for National Development: NSO, CSO, Human Development Index, measuring inequality in income: Lorenz Curve, Gini coefficient. (8 hrs)

References:

1. Cochran W.G. (1977): Sampling Techniques, 3rd Ed., Wiley.
2. Des Raj and Chandok (1998): Sampling Theory, Narosa Publication.
3. Mukhopadhyay P. (1998): Theory and Methods of Survey Sampling, Prentice-Hall of India.
4. Murthy M.N. (1977): Sampling Theory and Methods, Statistical Publishing Society, Calcutta.
5. S. Sampath (2001): Sampling Theory and Methods, Narosa Publishers.
6. Sen A. (1997): Poverty and Inequality.
7. Singh D. and Chaudhary F.S. (1986): Theory and Analysis of Sample Survey Designs, New Age International Publishers.
8. Sukhatme P.V., Sukhatme B.V, Sukhatme S. and Ashok(1984): Sampling Theory of Surveys with Applications, ICAR publication.
9. Vic Barnett (2002): Sample Survey – Methods and Principles, Arnold Publishers.

Hard Core	STP405: Practical I: Based on STH404	No. of Credits: 3

Practical's on STH404 : Theory of Sampling

1. Determination of sample size.
2. PPSWR sample selection by (i) Cumulative Total method and (ii) Lahiri's method.
3. PPSWR sampling: Hansen-Hurwitz estimator and its sampling variance and Comparison of PPSWR sampling with SRSWR sampling based on PPS sample.
4. PPSWOR sampling: Horvitz-Thompson sampling strategy.
5. PPSWOR sampling: Sen- Midzuno sampling strategy.
6. PPSWOR sampling: Desraj's ordered estimator and Murthy's unordered estimator and their sampling variance and PPSWOR sampling : Rao-Hartley-Cochran strategy.
7. Cluster sampling with clusters of equal size.
8. Cluster sampling with clusters of unequal size.
9. Two stage sampling with SRSWOR at both the stages.
10. Two stage sampling with SRSWR at the first stage and SRSWOR at the second stage.
11. Ratio Method of estimation.
12. Regression method of estimation.
13. Two Phase sampling.
14. Two stage sampling with PPSWR at the first stage and SRSWOR at the second stage.

Soft Core	STP406: Practical II :Using EXCEL and R- Programming	No. of Credits: 3

EXCEL Exercises

1. Reading data and creating data, certain computations using data. Descriptive Statistics and construction of frequency distribution. (At least two practicals).
2. Listing probabilities for standard distributions and plotting its probabilities and distribution functions.
3. Plotting density functions and distribution functions for standard continuous distribution functions.
4. Finding probabilities of certain sets in case of discrete and continuous distribution functions and Finding probabilities and critical values.
5. User defined function using visual basic (VB) – Plotting some general distribution function and finding certain probabilities.
6. Computation of annual salary of a randomly drawn employee (create problem so as to use LOOKUP function) and finding her net payable tax according to that year's Income tax.
7. Using macro programming for certain iterative computing (at least two practicals.)

R-Programming

1. Simple R exercises, using – scan function, reading data from EXCEL and exercises, vectors, matrices, rbind and cbind
2. Exercises on Matrices.
3. Reading data from text file. Data frames , names etc., Exercises based on these data and exercises on graphics
4. Exercises using iterative computations.
5. Functions in R Exercises - 1
6. Functions in R Exercises - 2
7. Generating a sample from general discrete distribution
8. Generating a sample from general continuous distribution
9. Verification law of large numbers and central limit theorem.

Open Elective	STE451: STATISTICAL METHODS	No. of credits: 3

Unit I:

Statistics: meaning and role as a decision making science, Data-types and scales of measurement. Descriptive Statistics - measures of central tendency, positional averages, measures of dispersion, skewness and kurtosis - Definition and properties. Presentation-tables, diagrammatic and graphical methods. Exploratory Data Analysis using descriptive measures and graphical tools. (08 hrs.)

Unit II:

Probability theory: random experiment, simple events, sample space - types of events, probability of an event, rules of probability, conditional probability, Bayes' theorem.

Probability distributions: random variables - discrete and continuous type, Bernoulli, Binomial, Poisson and normal distributions - applications. (10 hrs.)

Unit III:

Sampling methods - population and sample, parameter and statistic, concept of a random sample, simple random sampling, stratified sampling, systematic sampling, sample size determination. (8 hrs.)

Unit IV:

Correlation: bivariate data, correlation, scatterplot, correlation coefficient and its properties, testing for correlation coefficient, rank correlation.

Regression: linear relationship, linear regression model, simple linear regression, fitting the regression model, coefficient of determination, standard error of the estimated model. Testing regression coefficients. (10 hrs.)

References:

1. R.C. Campbell.(1974) : Statistics for Biologists, Cambridge University Press
2. Christopher Chatfield (1981) : Statistics for Technology, Chapman and Hall
3. Douglas A. Lind, William C. Marchal, Samuel A. Wathen (2012), "Basic Statistics for Business & Economics" McGraw-Hill Education
4. Harry Frank and Steven C. Athoen (1997) : Statistics: Concepts & Applications, Cambridge University Press.
5. J.Medhi (1992): Statistical Methods : An Introductory Text, Wiley Eastern Limited.

Hard Core	STH452 : DISTRIBUTION THEORY	No. of credits: 4

Unit-I

Random experiments and its sample spaces, random variables, cdf, pdf and pmf, absolutely continuous and discrete distributions. Continuous univariate distributions : Weibull, lognormal, Pareto, Laplace, Cauchy, Logistic, inverse Gaussian distributions, extreme value distributions. – Properties and applications. Generating functions- probability generating function, moment generating functions. Truncated distributions. (12 hrs)

Unit II

Functions of random variables and their distributions using Jacobian of transformation. Probability integral transformation. Independence, sum of independent random variables, convolutions, conditional expectation. Independence of mean and variance of a random sample from normal population. (12 hrs)

Unit III

Order statistics –their distributions and properties, joint and marginal distributions of order statistics. Distributions of range and median. Sampling distributions. Concepts of non-central distribution. Distribution of Quadratic forms under normality. (09 hrs)

Unit V

Multivariate normal distribution. Marginal and conditional distribution and properties. Independence of sample mean vector and sample covariance matrix. Wishart distribution-its properties and application. **(**10 hrs)

References:

1) Arnold B.C., Nagaraja H.N. and Balakrishna N. (2008): First Course in Order Statistics, John Wiley.
2) Anderson T.W.(1984) An Introduction to Multivariate Analysis., 2nd edition, John Wiley.
3) Johnson N.L., Kotz S and Balakrishna N (1994): Continuous Univariate Distributions-1, John Wiley.
4) Johnson N.L., Kotz S and Balakrishna N (1994): Continuous Univariate Distributions-2, John Wiley.
5) Johson N.L and Kemp (1992): Univariate Discrete Distributions, John Wiley.
6) Kendal M.G. and Stuart A. (1977): The advance Theory of Statistical (Vol.1) Charles Griffin and Company Limited.

7) Rohatgi V.K., A. K. Md. Ehsanes Saleh (2011): Introduction to Probability Theory and Statistics, Wiley Eastern.

8) Rao CR. (1995): Linear Statistical Inference and Its Applications (Wiley Eastern) 2nd Ed.

9) Parimal Mukhopadhyay (2012) Theory of Probability,World Scientific.

Hard Core	STH453: THEORY OF POINT ESTIMATION	No. of credits: 4

Unit-I

Parametric models, likelihood function; examples from standard discrete and continuous models.

Information in data. About the parameters as variation in 1ikelihood function, concept of no information, sufficiency, Neyman factorizability criterion, likelihood equivalence. Fisher information for single and several parameters. (10 hrs)

Unit-II

Minimal sufficient statistic, Exponential families and Pitman families.

Minimum Variance Unbiased Estimation, unbiasedness, locally unbiased estimators, minimum variance, locally minimum variance, mean squared error, Cramer-Rao lower bound approach. (10 hrs)

Unit-III

Minimum variance unbiased estimators(MVUE), Rao-Blackwell theorem, completeness, Lehman-Scheffe theorem, necessary and sufficient condition for MVUE. (10 hrs)

Unit-IV

Consistent estimation of real and vector valued parameter, invariance of consistent estimator under continuous transformation: Consistency of estimators by method of moments and method of percentiles, mean squared error criterion, Asymptotic relative efficiency. Consistent asymptotic normal (CAN) estimator. (10 hrs)

Unit-V

Method of Maximum Likelihood: notion, MLE in exponential family, Cramer Family, Multinomial with all probabilities depending on a parameter, solutions to likelihood equations, method of scoring, Newton-Raphson and other iterative procedures. Fisher lower bound to asymptotic variance, extension to multiparameter case (without proof). (10 hrs)

References:

1. Casella G. and Berge R.L. (2002): Statistical Inference, 2nd Ed., Thomson- Duxbury, Singapore.
2. Kale B.K. and Muralidharan (2015): Parametric Inference, An Introduction, Alpha Science International Limited.
3. Kendall M.G. and Stuart A. (1968): The Advanced Theory of Statistics, Vol.II, Charles Griffin and Co.
4. Lehman E.L. (1986): Theory of Point Estimation, John Wiley.
5. Rao C.R. (1973): Linear Statistical Inference and Its Applications. Wiley Eastern.
6. Rohatgi V.K. and A.K.L. Salah (2001): An Introduction to Probability and Mathematical Statistics. Wiley Eastern.
7. Silvey S.D. (1970): Statistical Inference. Chapman and Hall.
8. Zacks S. (1981): Parametric Statistical Inference, Pergamon Press.

Hard Core	STH454: ECONOMETRICS	No. of credits: 4

Unit-I

Introduction to Econometrics. Nature of econometric study. Simple linear regression, multiple linear regression, basic assumptions. Ordinary Least Squares (OLS) estimation and their properties. Use of prior information. Restricted least squares estimators Tests of hypothesis about regression coefficients and ANOVA. Mixed regression estimator.

(12 hrs)

Unit-II

Prediction – best linear unbiased predictor. Regression diagnostics and specification tests: Residual analysis for identifying influential observations, recursive residuals and their applications. Subset selection of explanatory variables, Mallows C_p-statistic. Introduction to Logistic regression model. Estimation and testing the significance of the coefficients.

(10 hrs)

Unit-III

Violation of basic ideal conditions: Disturbance with non-zero mean; asymptotically unco-operative regressors. Multicollinearity – its consequences and testing. Ridge estimator and its properties. Ridge regression. Stochastic regressors, autoregressive models, Instrumental variables, Errors in variables. (12 hrs)

Unit-IV

Heteroscedasticity, tests for heteroscedasticity. Generalised Least Squares (GLS) estimators and its properties. Feasible generalized least squares estimators. Grouping of observations. Sets of Regression Equations. Auto correlation, its consequences and testing for autocorrelation. Estimation. (10 hrs)

Unit-V

Simultaneous equation models. Identification problem. Identification using linear homogeneous restrictions on structural parameters, rank and order conditions.

Estimation in simultaneous equation models – Indirect Least Squares (ILS) estimators, Two State Least Squares (2SLS) and their properties. Three stage least squares estimation. (10 hrs)

References:

1. Badi H. Battagi (2002): Econometrics, 3rd Ed., Springer.
2. B.Abraham and Ledotter, J. (1983) Statistical Methods for Forecasting, John Wiley & Sons
3. Draper N.R. and Smith H. (1998): Applied Regression Analysis, 3rd Ed., John Wiley and Sons, Inc.
4. Dilip M. Nachane(2006): Econometrics-Theoretical Foundations and Empirical Perspective, Oxford University Press, New Delhi.
5. Fombay T.B., Hill R.C. and Johnson S.R. (1988) *Advanced Econometric Methods*, Springer- Verlag.
6. Greene W.H. (1993): Econometric Analysis, Macmillan, New York.
7. Johnston J. (1984): Econometric Methods, 3rd Ed., McGraw Hill.
8. Johnston J. and Dinardo J. (1997): Econometric Methods, 4th Ed., McGraw-Hill Companies.
9. G.S. Maddala (1977): Econometrics, McGraw-Hill Inc.
10. Peter Schmidt (1976): Econometrics, Marcel Dekker.
11. Damodar N. Gujarati (2003) "Basic Econometrics", McGraw Hill

Soft Core	STS455: ACTUARIAL STATISTICS	No. of credits: 3

Unit 1

Introduction to life Insurance, insurance contracts, survival models. Future lifetime random variable, force of mortality, actuarial notation, curtate future lifetime, complete and curtate expected future lifetimes, Life tables, Fractional age assumptions, Uniform distribution of deaths, constant force of mortality, Select life tables. (14 hrs)

Unit 2

Compound interest and discounting, force of interest, benefit payable at the time of death, term life insurance. Whole life insurance: the continuous case, the annual case, the 1/*m*thly case. Recursions, term insurance, pure endowment, endowment insurance.

Annuities-certain, annual life annuities, whole life annuity-due, term annuity-due, whole life immediate annuity, term immediate annuity. Annuities payable continuously. Annuities payable *m* times per year. (14 hrs)

Unit 3

Loss at issue random variable, principles of premium calculation. Fully continuous premiums, fully discrete premiums, true mthly payment premiums. Gross premiums.

Reserves, Fully continuous reserves, fully discrete reserves. (10 hrs)

References:

1. David C.M.Dickson, Mary R. Hardy and Howard R Waters (2009) "Actuarial Mathematics for Life Contingent Risks", Cambrigge University Press.
2. Shailaja R Deshmukh (2009) "Actuarial Statistics", University Press (India) Private Limited, Hyderabad.
3. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1997), "Actuarial Mathematics", Second Edition, The Society of Actuaries.

Hard Core	STP456:Practical III: Practicals based on STH454	No. of credits: 4

Practicals based on STH454: ECONOMETRICS

1. Simple linear regression.
2. Multiple linear regression.
3. Testing the significance of regressors and ANOVA.
4. Restricted least squares estimators and Testing linear restrictions.
5. Residual Analysis
6. Best Linear Unbiased Prediction (BLUP) and confidence interval.
7. Testing for autocorrelation and fitting auto-correlated model.
8. Testing Heteroscedasticity in multiple linear regression model.
9. Recursive residuals and their applications.
10. Feasible generalised least squares estimation.
11. Multicollinearity.
12. Best subset selection based on MSE, R^2 and Mallows C_p-criterion.
13. Ridge regression.
14. Indirect Least squares(ILS)
15. Two stage least squares (2SLS) estimation.

Soft Core	STP457: Practicals IV: Based on Theory papers (STH452, STH453 & STS455)	No. of credits:3

Practical Based on STH452: DISTRIBUTION THEORY & STH 453: THEORY OF POINT ESTIMATION

1. Generating observations from mixture distributions.
2. Fitting truncated distributions by method of moments (Newton-Rapson method) -1
3. Fitting truncated distributions by method of mle (Newton-Rapson method) -2
4. Maximum likelihood estimator (when closed form solution does not exist)
5. Method of scoring -1
6. Method of scoring -2

Practical Based on STS455: ACTUARIAL STATISTICS

1. Future lifetime random variable and related measures.
2. Computation of various measures using Gompertz and Makeham's Model.
3. Life Tables under UDD assumption and constant force of mortality. Construction of Select Life Tables.
4. Calculation of Premiums and Annuities.
5. Actuarial present values of insurance schemes.
6. Calculation of Benefit Reserves.

Open Elective	STE501 : Statistical Testing in Data Analysis	No. of credits: 3

Unit 1

Population and sample, parameter, statistic, estimator, statistical properties of estimators.

Basic concepts concerning testing of hypotheses, procedure for hypothesis testing. Null hypothesis, alternate hypothesis, statistical test procedures, test statistic, two types of errors, level of significance, p-value, size and power of the test. One sided and two sided test procedures. Parametric and nonparametric tests. (10 hours)

Unit 2

Assumptions, test procedures and examples - One sample Z test, hypothesis testing of means, hypothesis testing for differences between means under equal variance and unequal variances, paired t-test, tests for proportions. Sample size and its determination.

Hypothesis testing for comparing a variance to some hypothesized population variance, testing the equality of variances of two normal populations, hypothesis testing of correlation coefficients, confidence intervals. (14 hrs)

Unit 3

Non-parametric tests, sign test, Wilcoxon signed rank test, Wilcoxon rank sum test-Mann-Whitney test, Contingency tables - Chi-square test for independence of attributes,

Principles of design of experiments, basic principle of ANOVA, ANOVA – CRD, RBD, LSD. Tukey multiple comparison test with equal sample sizes, Tukey-Kramer test with unequal sample sizes. (16 hrs.)

References:

1. J.Medhi (1992): Statistical Methods : An Introductory Text, Wiley Eastern Limited.
2. Douglas A. Lind, William C. Marchal, Samuel A. Wathen (2012), “Basic Statistics for Business & Economics” McGraw-Hill Education

Hard Core	STH502: TESTING OF HYPOTHESES	No. of credits: 4

Unit-I

Framing of null hypothesis, critical region, test functions, two kinds of error, size of a test, p-value, power function, level of a test. Randomized and non-randomised tests, most powerful tests in class of size α - test, Neyman-Pearson lemma, MP test for simple null against simple alternative hypothesis. Distributions with monotone likelihood ratio, UMP tests for one sided null against one sided alternatives,. Extension of these results in Pitman family when only upper or lower end points depend on the parameter. (12 hrs)

Unit-II

Non-existence of UMP test for simple null against two sided alternatives in one parameter exponential family. Neyman-Pearson generalized lemma. Unbiasedness for hypothesis testing – concept with application to one parameter exponential family. (8 hrs)

Unit-III

Interval estimation, confidence level, construction of confidence intervals by inverting a test statistic and using pivots. Shortest expected length confidence interval, evaluating interval estimators using size and coverage probability and test-related optimality. Uniformly most accurate one-sided confidence interval and its relation to UMP test for one sided null against one sided alternative hypothesis. (10 hrs)

Unit-IV

Likelihood Ratio Test (LRT), Asymptotic distribution of LRT statistic, Pearson's chi-square test for goodness of fit, Bartlett's Test for homogeneity of variances. Large Sample Tests – Wald and Score tests. (10 hrs)

Unit-V

Non parametric Tests: One sample test: Test based on total number of runs, the ordinary sign test, the Wilcoxon signed - rank test, the Kolmogorov-Smirnov one sample goodness of fit test. Two-sample tests: Sign test, Wilcoxon signed rank test, the median test, the Wilcoxon-Mann-Whetney test, the Kolmogorov Smirnov two sample test. (10 hrs)

References:

1. Casella G. and Berger R.L. (2002): Statistical Inference, Wadsworth Grou.
2. Gibbons J.D. (1971): Nonparametric Inference, McGraw-Hill.
3. Kale B.K. (1999): A First Course on Parametric Inference, Narosa Publishing House.
4. Kendall M.G. and Stuart A. (1968): The Advanced Theory of Statistics, Vol.II, Charles Griffin and Co.
5. Lehmann E.L. (1986): Testing Statistical Hypotheses, John Wiley.
6. Pratt T.W. and Gibbons, J.D. (1981): Concepts of Nonparametric Theory, Springer.
7. Rao C.R. (1973): Linear Statistical Inference and Its Applications, Wiley Eastern.
8. Silvey S.D. (1970): Statistical Inference, Chapman & Hall.

Hard Core	STH503: STOCHASTIC PROCESSES	No. of credits: 4

Unit I

Introduction to Stochastic Processes; classification according to state space and time domain. Countable state Markov Chains(MC's), Chapman-Kolmogorov equations; calculation of n-step transition probability and its limit. (8 hrs)

Unit II

Stationary distribution, classification of states, transient MC; random walk and gambler's ruin problem; Statistical inference in MC. (8 hrs)

Unit III

Discrete state space continuous time MC: Kolmogorov-Fel1er differential equations; Poisson process, birth and death process; Applications to queues and storage problems. Brownian motion process and its properties, Wiener process as a limit of random walk; first-passage time and other problems. (12 hrs)

Unit-IV

Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem; study of residual 1ife time process. Stationary process: weakly stationary and strongly stationary processes. (10 hrs)

Unit-V

Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Martingale in discrete time, inequality, convergence. (10 hrs)

References:

1) Ross S.M.(1983): Stochastic Processes, John Wiley & Sons.
2) A.K. Basu (2003): Introduction to Stochastic Processes, Narosa Publishers.
3) Bhat B.R. (2000): Stochastic Models: Analysis and Applications, New Age International.
4) Cinlar E.(1975):Introduction to Stochastic Processes, Prentice Hall.
5) Karlin S. and Taylor, H.M. (1975): A First Course in Stochastic Processes, Vol.I, Academic Press.
6) Medhi J. (1982): Stochastic Processes, Wiley Eastern.

Soft Core	STS504: TIME SERIES ANALYSIS	No. of credits : 3

Unit-I

Simple Descriptive Techniques: time series plots, trend, seasonal effect.

Tests for trend and seasonality: estimation and elimination of trend and seasonal components. Exponential and moving average smoothing.

Time Series as discrete parameter stochastic process. Stationarity, autocovariance and autocorrelation function and their properties. Partial autocorrelation function. (8 hrs)

Unit-II

Probability Models: White noise model, random walk, linear processes, Moving Average (MA), Autoregressive (AR), ARMA and ARIMA, seasonal ARIMA models. Invertibility. ACF and PACF of these processes. Sample ACF and PACF. Model identification. (12 hrs)

Unit-III

Model Building: Estimation of mean, autocovariance function and autocorrelation function. Estimation of AR models – Yule-Walker equations, estimation of MA model and ARMA models. Order selection in AR and MA models. (10 hrs)

Unit-IV

Forecasting: Forecast mean square error (FMSE), Least squares prediction. BLUP. Box-Jenkins forecasting. Forecasting through exponential smoothing and Holt-Winters smoothing. Residual analysis and diagnostic checking. Nonstationary time series models and their identification. (10 hrs)

References:

1. Box GEP and Jenkins G.M. (1976): Time Series Analysis: Forecasting and Control, Holden-day, San Franscisco.
2. Brockwell P.J. and Davis R.S. (2002): Introduction to Time Series and Forecasting, 2nd Ed., Springer.
3. Chatfield C. (1996): The Analysis of Time Series An Introduction, Chapman & Hall.

4. Janacek G. (2001): Practical Time Series Arnolds Texts in Statistics.
5. Kendall M.G. and Ord J.K. (1990): Time Series, 3rd Ed., Edward Arnold.
6. Montgomory D.C. and Johnson L.A. (1977): Forecasting and Time Series Analysis, McGraw Hill.
7. K. Tanaka (1996): Time Series Analysis, Wiley Series.
8. Dilip M. Nachane (2006) " Econometrics- Theoretical Foundations and Empirical Perspectives", OUP India

Soft Core	STS505: MULTIVARIATE ANLAYSIS	No. of credits: 3

Unit I

Multivariate normal distribution – maximum likelihood estimators of the parameters, multiple and partial correlation coefficients, Assessing the assumptions of normality – Q-Q plot, Chi-square plot, transformations to near normality.

Inference problems in multivariate normal distribution – Hotelling's T^2 & Mahalanobis D^2 – statistics, likelihood ratio tests – one sample and two sample problems, q-sample problem, test for symmetry, confidence regions, simultaneous confidence statements. Independence of subvectors, sphericity test. Test for covariance matrices (Statistics and their distributions- Statements only and applications) (12 hrs)

Unit II

Principal Component Analysis (PCA) – definition and properties, graphing the principal components, sample principal components, interpretation of zero, small and repeated eigenvalues, component loadings and component correlations, the problem of scaling, tests of hypotheses.

Canonical Correlation Analysis – canonical variates and canonical variables, sample canonical variates, sample canonical correlations, inference problems. (10 hrs)

Unit III

Classification and Discrimination problems – concepts of separation and classification, Bayes', minmax and Fisher's criteria, classification rules based on Expected Cost of Misclassification (ECM) and Total Probability of Misclassification (TPM), classification with two multivariate normal populations (equal and unequal covariance matrices), evaluating classification rules, classification with several populations, Fisher's linear discriminant function, tests associated with discriminant functions.

(10 hrs)

Unit IV

Factor Analysis: orthogonal factor model, factor loadings, estimation of factor loadings, factor scores. Cluster Analysis: distances and similarity measures, hierarchical clustering methods, K – means method. (6 hrs)

References :

1. T.W.Anderson (1984): An Introduction to Multivariate Analysis, 2nd Ed., John Wiley.
2. Bernard Flury (1997): A First Course in Multivariate Statistics, Springer Texts in Statistics.
3. A.M.Kshirasagar (1972): Multivariate Analysis, Marcel Dekker.
4. K.V.Mardia, J.T. Kent and J.M. Bibby (1979): Multivariate Analysis, Academic Press.
5. C.R. Rao (1973): Linear Statistical Inference and its Applications, Wiley Eastern.
6. Richard Arnold Johnson and Dean W. Wichern (2007) Applied Multivariate Statistical Analysis, Prentice Hall.
7. Alvin C. Rencher, William F. Christensen (2012), "Methods of Multivariate Analysis" John Wiely.

Hard Core	STP506:Practical V: Practicals Based on Theory papers (STH502 & STS505)	No. of credits: 3

Practicals on STH502: Testing of Hypothesis:

1) Computing size of the test, power of the test and plotting power function.
2) Most powerful tests (Continuous as well as discrete distributions).
3) UMP one sided test including plotting of power function: Discrete distributions.
4) UMP one sided test including plotting of power function: Continuous distributions.
5) UMPU test based on one parameter exponential family.
6) Interval estimation: Pivotal approach and Interval estimation: Through the acceptance region of one sided UMP test and two sided UMPU tests for one parameter exponential family.
7) Likelihood ratio test for finite sample based on one and two independent sample from normal distribution and exponential distribution.
8) Bartlett test for homogeneity of variances.
9) Wald and Score test for large samples.
10) Non parametric test 1: Tests based on one and two sample sign and Wilcoxon signed rank test, Kolmogorov Smirnoff goodness of fit test, run test.
11) Non parametric test 2: Two and k-sample median test, two sample Wilcoxon-Mann Whitney test, two sample Kolmogorov Smirnoff test.

Practicals on STS505 : Multivariate Analysis

1. Assessing normality of data – Q-Q plot and Chi-Square plot.
2. Exercises on bivariate normal
3. Hotellings T^2 statistic – I (one sample and two sample problem)
4. Principal Component Analysis and Cananical Correlation
5. Classification and discrimination –II
6. Factor Analysis

Soft Core	STP508: Practical VI: Practicals Based on Theory papers (STS503 & STH504)	No. of credits: 3

Practicals on STS504: Time Series Analysis

1. Estimation and elimination of trend component. Variate difference method.
2. Estimation and elimination of Seasonal Component
3. Examining Stationarity. Sample ACF and PACF.
4. Identification of moving average (MA) and Auto regressive(AR) process and its order selection.
5. Yule-Walker estimation for AR(p) model.
6. Fitting MA model using Least squares regression.
7. Residual Analysis and Diagnostic checking.
8. Identification of ARIMA(p d q) process and order selection .
9. Goodness of fit of the model based on AIC and Ljung-Box criteria.

Practicals on STH503 : Stochastic Processes

1. Sample path of a Markov Chain.
2. Stationary probabilities of a Markov Chain.
3. Poisson process Homogeneous and non-homogeneous.
4. Weiner process, hitting time.
5. Branching process

Hard Core	STH551: DESIGN AND ANALYSIS OF EXPERIMENTS	No. of credits: 4

Unit-I

Gauss-Markov set-up, normal equations and least squares estimators, error and estimation spaces, Variances and Covariances of least squares estimates, estimation of error variance, least squares estimators, simultaneous estimates of linear parametric functions.

Tests of hypothesis for one and more than one linear parametric functions, Confidence intervals and regions, multiple comparison tests, simultaneous confidence intervals. (12 hrs)

Unit-II

Introduction to designed experiments, General block design information matrix (C-matrix) and its properties; connectedness, balance and orthogonality, Intra block analysis (contrast estimators, multiple comparisons and testing of linear hypothesis). (12 hrs)

Unit-III

Balanced incomplete block design (BIBD) – Definition and relations among the parameters, Intrablock analysis. Youden square design (YSD). Intra Block Analysis of YSD (10 hrs)

Unit-IV

General factorial experiments, factorial effects - best estimators and testing the significance of factorial effects, study of 2 and 3 level factorial experiments in randomized blocks; complete and partial confounding of 2 and 3 level symmetric factorial experiments; notion of fractional factorial experiments for factors with 2 levels. (10 hrs)

Unit-V

Analysis of covariance for CRD and RBD designs. Missing plot techniques for RBD. (06 hrs)

References:

1) Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.
2) Angela Dean and Daniel VOSS (1999): Design and Analysis of Experiments. Springer.
3) Das M.N. and Giri N.C. (1979): Design and Analysis of Experiments, 2nd Ed., Wiley.
4) Giri N.C. (1986): Analysis of Variance. South Asian Publishers.
5) Hinkleman and Kempthrone C. (1994): Design and Analysis of Experiments, Vol.I, John Wiley.
6) Joshi D.D. (1987): Linear Estimation and Design of Experiments,Wiley Eastern.
7) Montgomery D.C. (2001): Design and Analysis of Experiments, John Wiley.
8) Rao C.R. (1973) Linear Statistical Inference and its Applications. Wiley Eastern.
9) R B Bapat (2011), "Linear Algebra and Linear Models", Hindustan Book Agency.
10) Parimal Mukhopadhyay (1999) "Applied Statistics", Books and Applied.

Hard Core	**STP555: Practical VII: Based on All Theory papers :** **STH551-Design and Analysis of Experiments and other Soft Course Papers.**	**No. of credits: 3**

Practicals on STH551: Design and Analysis of Experiments

1) Linear estimation: Estimability of linear parametric function, Least squares estimators.
2) Testing Linear hypothesis. Analysis of one way and two way classified data.
3) Incomplete Block Design-1: computations of Incidence matrix, C-matrix, Q-matrix, estimability of contrasts, Determining estimable and non estimable treatment contrasts. Best estimates and testing linear restrictions
4) Incomplete Block Design-2 : Intra block Analysis.
5) Balanced Incomplete block design (BIBD): Verifying the relationship between the parameters of the design, computation of C-matrix of the design, best estimates.
6) BIBD: Intra block Analysis
7) Analysis of Youden square Design.
8) Analysis of covariance ANCOVA.
9) Analysis of 2^3 /2^4 Factorial Experiment : Yates table, estimation of main effect and interaction effect , testing the significance of factorial effects.
10) Analysis of 3^2 Factorial Experiment.
11) Complete Confounding 2^3/2^4 and 3^2/3^3 Factorial Experiment.
12) 2^3 Partial Confounding
13) 3^2 Partial Confounding
14) Missing Plot Techniques

Soft Core	**STS553 : Statistical Finance**	No. of credits: 3

Unit I

Basic concepts of financial markets and financial systems. Functions of financial markets.

Interest rates, continuous compounding, present value analysis - effective interest rate, present value and future value.

Modeling returns: lognormal model, random walk model, modeling through geometric Brownian motion process. (10 hrs)

Unit II

Portfolio theory – mean variance portfolio theory. Risk and return, risk free interest rate. One risky asset and one risk free asset. Two risky assets. Sharpe's ratio, tangency portfolio, optimal mix of portfolio. Market portfolio, beta, security market line, and capital asset pricing model (CAPM) and their assumption.

Value at Risk (VaR) – Nonparametric and parametric estimation of VaR , VaR for a derivative and for a portfolio of assets. (10 hrs)

Unit III

Forward contracts and Futures. Call and put options, European option and American options, short and long positions. Financial derivatives, options, pricing via arbitrage, law of one price. Risk neutral valuation, arbitrage theorem. Risk neutral probabilities- Binomial model, and multi-period model. (10 hrs)

Unit IV

The Black-Scholes formula and assumptions. Properties of the Black-Scholes option cost. Delta, gamma and other Greeks.

Volatility and estimating the volatility parameter. Implied volatility. Pricing American options. Call options on dividend-paying securities. (10 hrs)

References:

1. Sheldon M. Ross (2003): "*An elementary introduction to Mathematical Finance*", Cambridge University Press.
2. David Ruppert (2004) *"Statistics and Finance an Introduction"* – Springer International Eddition.
3. John C. Hull (2008) "*Options, Futures and other derivatives*", Pearson Education India.
4. Cuthbertson K and Nitzsche D (2001): "*Financial Engineering - Derivatives and Risk Management*", John Wiley & Sons Ltd.
5. David G Luenberger(1998): "*Investment Science*", Oxford University Press.
6. Paul Wilmott (2000): "*Quantitative Finance*", John Wiley & Sons.

Practicals on STS553 : Statistical Finance

1. Exercises on interest rates and net present values
2. Returns, log returns, plots, value at risk
3. Option pricing - Binomial tree and multiperiod option pricing
4. Option pricing through Black-Scholes formula when dividends are (i) not paid and (ii) paid.
5. Implied volatility using MACRO programming.

Soft Core	STS552 : Operations Research	No. of credits: 3

Unit I

Linear Programming Problem (LPP) – definition, formulation, simplex method – canonical form, improving nonoptimal basic feasible solution (b.f.s), conditions for optimality, conditions for unboundedness. Two phase method, Big M method. Convex sets, geometry of simplex method- extreme point and b.f.s., existence of b.f.s., existence of optimal b.f.s. (12 hrs)

Unit II

Duality theory of LPP – weak duality theorem and its properties, the fundamental duality theorem, complementary slackness theorem. Dual simplex method. Sensitivity analysis. Integer programming-cutting plane technique, Gomory's algorithm for pure integer program. (10 hrs)

Unit III

Dynamic Programming - Multistage decision making problems, Bellman's principle of optimality, recursive nature of computation, applications of dynamic programming, probabilistic dynamic programming. (8 hrs)

Unit IV

Inventory theory – nature of inventory problem, motives for carrying inventory, deterministic inventory model with decay, finite horizon model with variable demand rate. Probabilistic inventory models – continuous review and periodic review systems,

(s, S) policy, heuristic solution of lot size reorder point model [(Q, r) policy]. (10 hrs)

References:

1. D.Gross and C.M.Harris (1985): Fundamentals of Queuing Theory, 2nd Ed., John Wiley.
2. G. Hadley (1975): Linear Programming, Addison Wesley.
3. Katta G. Murthy (1976): Linear and Combinatorial Programming, John Wiley & Sons.
4. N.S. Kambo (1991): Mathematical Programming Techniques, Affiliated East-West Press.
5. H. A. Taha (2001): Operations Research – An Introduction (6th Edition), Prentice-Hall, India.
6. B.D. Sivazlian and L.E. Stanfel (1975): Analysis of Systems in Operations Research, Prentice-Hall.
7. H.G.Daeallenbach & John A.George(1978): Introduction to Operations Research Techniques, Allyn & BaconInc.

Practicals on STS 552: Operations Research

1. Simplex Method
2. Two phase method
3. Big M method
4. Dual LPP and Dual Simplex method.
5. Integer Programming

Soft Core	STS554 : Financial Time Series	No. of credits: 3

Unit 1: Financial time series and their characteristics: Assets and Markets, Asset Returns, Distribution of returns, empirical properties of returns, Market Indexes. [9 hrs]

Unit 2: Stationary process. Autocorrelation function, Simple Autoregressive, Moving Average, Autoregressive moving average(ARMA) and seasonal ARIMA models.

Unit root non-stationarity, Testing for unit roots, Dickey-Fuller Tests, and its extension. Co-integration and error correction models, [12 hrs]

Unit 3: Conditional Heteroscedastic models: Volatility, Characteristic of volatility, model building. The Autoregressive Conditional Heteroscedastic (ARCH) model. Properties of ARCH model. Order determination, estimation and forecasting. [10 hrs]

Unit 4: The GARCH model and properties. Estimation and forecasting. Elementary properties of EGARCH and M-GARCH models.. [06 hrs]

References:

1. Rucy S. Tsay (2009): *Analysis of Financial Time Series*, 2nd Ed. Wiley Series in Probability and Statistics, ISBN 978-81-265-2369-6.
2. Christian Gourieroux G and Joann Jasiak (2005): *Financial Econometrics*, New Age publications, ISBN 81-224-1697-7.
3. Dilip M.Nachane (2006) *ECONOMETRICS, Theoretical Foundations and Empirical Perspectives*, ISBN-10-0-19-564790-4, Oxford University Press, New Delhi.
4. David Ruppert (2004) "Statistics and Finance an Introduction" – Springer International Edition.

Practicals on STS554: Financial Time Series:

1. Plot of financial time series and examining the features of the series.
2. ACF and PACF of Return series and squared Return series.
3. Fitting ARMA model.
4. Dickey Fuller Unit Root Test.
5. Co-integration and error correction models
6. Fitting ARCH model
7. Fitting GARCH Model.
8. Residual Analysis and Diagnostic Checking

Soft Core	STS507 : SURVIVAL ANALYSIS	No. of credits: 3

Unit-I

Complete and censored samples, Type I, Type II, and random censoring, Life distributions -Exponential, Gamma, Weibull, Lognormal, Pareto, Proportional Hazards family. Estimation of parameter for exponential and gamma distribution under various censoring situations. (10 hrs)

Unit-II

Life tables: Standard methods for uncensored and censored data; Asymptotic properties of estimates under a random censorship model. Failure rate, mean residual life and their elementary properties.

Estimation of survival function - Kaplan Meier Estimator, Greenwood's formula. Other life table estimators. (10 hrs)

Unit-III

Fully parametric analysis of dependency – accelerated life model – simple form, log logistic accelerated life model, proportional hazards model – relation with accelerated life model. (10 hrs)

Unit-IV

Semi-parametric regression for failure rate – Cox's proportional hazards model with one and several covariates, log likelihood function, log linear hazards, test for regression coefficients, Discrete failure time: ties. (10 hrs)

References:

1. Cox D.R. and Oakes D. (1984): Analysis of Survival Data, Chapman and Hall, New York.
2. Kalbfeisch J.D. and Prentice R.L. (2002): The Statistical Analysis of Failure Time Data, John Wiley& Sons, Inc. 2nd Edition.
3. Lawless J.F. (2002): Statistical Models and Methods for Lifetime Data, John Wiley & Sons, Inc.
4. Miller R.G. (1981): Survival Analysis, John Wiley& Sons, Inc.
5. Hosmer D.W., Lemeshow S. and May S.(2008): Applied Survival Analysis: Regression Modeling of Time-to-Event Data (2nd Edition), John Wiley& Sons, Inc.

Soft Core	STS557 : DATA MINING TECHNIQUES	No. of credits :3

Unit I

Data Mining – motivations and importance, Knowledge Discovery in Databases (KDD) process - search, induction, querying, approximation and compression. Kinds of data considered for data mining, basic data mining tasks, data mining issues, Data Mining models - predictive and descriptive, inter-connections between Statistics, Data Mining, Artificial Intelligence and Machine Learning. Applications tof data mining. (10 hrs)

Unit II

Data marts, databases and data warehouses - OLTP systems, multidimensional models – data cubes, OLAP operations on data cubes, multidimensional schemas.

Data pre-processing – data cleaning, data integration, data transformation and data reduction.

Visualisation techniques for multidimensional data - scatter plot matrix, star plots, Andrews plots, Chernoff faces, parallel axis plots. (10 hrs)

Unit III

Supervised learning – classification and prediction, statistical classification-Linear Discriminants-Mahalanobis' linear discriminant, Fisher's linear discriminant; Bayesian classifier, Regression based classification, k-NN(nearest neighbour) classifier. Tree classifiers-decision trees, ID3 algorithm CART. (08 hrs)

Unit IV

Unsupervised learning – Clustering problem, similarity and distance measures, Partitioning algorithms-k-means & k-medoids(PAM) algorithms. Density based clustering algorithms (DBSCAN). (06hrs)

Unit V

Computational methods useful in datamining: Expectation-Maximisation (EM) algorithm, Genetic algorithm, Markov Chain Monte Carlo(MCMC) method. Resampling Techniques - Gibbs sampler, Bootstrap sampling, (06 hrs)

References:

1. .Jiawei Han, Micheline Kamber: (2002): Data Mining-Concepts and Techniques, Morgan Kaufman Publishers, U.S.A
2. Margaret.H.Dunham (2005): Data Mining-Introductory and Advanced Topics, Pearson Education.

3. Trevor Hastie, Robert Tibshirani & Jerome Friedman (2001):The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, New York,
4. Michael Berthold, David J. H and (Eds): (2003) Intelligent Data Analysis - An Introduction (2nd Ed), Springer.
5. J.P. Marques de Sa: (2001):Pattern Recognition - Concepts, Methods and Applications, Springer 6.
6. Rajan Chattamvelli: (2009): Data Mining Methods, Narosa Publishing House.

Practicals on STS557: Data Mining Techniques

1. Decision Tree for classification and Classification using ANN
2. Bayesian classifier
3. k-NN classifier
4. Clustering techniques
5. Association Rule Mining

Soft Core	STS566 : BAYESIAN INFERENCE	No. of credits : 3

Unit-I

Limitations of empirical and logical theories of probability, Subjective probability, determination of subjective probability, likelihood function, prior distribution, posterior distribution. Bayes' theorem, methods of construction of priors and computation of the posterior distribution.

Natural conjugate family of priors for a model. Hyper parameters of a prior from conjugate family. Conjugate families for (i) exponential family models, (ii) models admitting sufficient statistics of fixed dimension. (10 hrs)

Unit-II

Enlarging the natural conjugate family by (i) enlarging hyper parameter space (ii) mixtures from conjugate family, choosing an appropriate member of conjugate prior family. Non informative, improper and invariant priors. Jeffrey's invariant prior. (10 hrs)

Unit-III

Bayesian point estimation: As a prediction problem from posterior distribution. Bayes estimators for (i) absolute error loss (ii) squared error loss (iii) 0-1 loss function. Generalization to convex loss functions. Evaluation of the estimate in terms of the posterior risk. (10 hrs)

Unit-IV

Bayesian interval estimation: Credible intervals. Highest posterior density regions. Interpretation of the confidence coefficient of an interval and its comparison with the interpretation of the confidence coefficient for a classical confidence interval.

Bayesian testing of hypothesis: Specification of appropriate form of the prior distribution for a Bayesian testing of hypothesis problem. Prior odds, Posterior odds, Bayes factor for various types of testing hypothesis problems depending upon whether the null hypothesis and the alternative hypothesis are simple or composite. Specification of the Bayes tests in the above cases. (10 hrs)

References:

1. Bernando J.M. and Smith A.F.M.: Bayesian Theory, John Wiley.
2. Berger J.O. (1988): Statistical Decision Theory and Bayesian Analysis, Springer- Verlag, New York Inc.
3. Degroot M.H.: Optimal Statistical Decisions, McGrow Hill.
4. Ghosh J.K., Delampady M. and Samanta T. (2006): An Introduction to Bayesian Analysis: Theory and Methods, Springer.
5. Leonard T. and Hsu J.S.J. (1999): Bayesian Methods: An Analysis for Statisticians and Interdisciplinary Researchers, Cambridge University Press.
6. Robert C.P. and Casella G.: Monte Carlo Statistical Methods, Springer-Verlag.

Practicals on PSTS566 : BAYESIAN INFERENCE

1) Bayes estimation under conjugate family, hyperparameters of the conjugate family and mixtures of conjugate families.
2) Bayesian credible interval, HPD credible interval from exponential family.
3) Estimation of posterior density, HPD credible intervals using importance sampling from exponential family.
4) Posterior density estimation, HPD credible intervals using Gibbs sampler.

Exercises can be done using WEKA software, which is freely downloadable.

Soft Core	STS558: NONPARAMETRIC REGRESSION	No. of credits: 3

Unit-I

Nature and scope of nonparametric regression Basic idea of smoothing, Smoothing histograms and nonparametric probability density function. Random design and fixed design model, Bin smoothers, running mean and running line smoothes. Univariate Kernel density estimation. Local regression estimate. (10 hrs)

Unit-II

Kernel Regression: Kernel smoothing, Local polynomial Kernel estimators, Kernel estimators of derivatives, computational aspects of Kernel smoothing, K-nearest neighbor (KNN) estimates. Computational aspects of K-NN estimators. (10 hrs)

Unit-III

Spline Smoothing: Roughness penalties, quantifying roughness of a curve, cubic splines, computational aspects of natural cubic splines, Orthogonal series estimators. (8 hrs)

Unit-V

Lack of Fit Tests: Testing the fit of a linear model. Lack of fit tests based on linear smoothers: Smoothing residuals, comparing parametric and nonparametric models, Introduction to additive models. Semiparametric regression models. (10 hrs)

References:

1. Clive Loader (1999): Local Regression and Likelihood, Springer.
2. Hardle (1990): Applied Non-parametric Regression, Cambridge University Press.
3. Hart J.D. (1997): Non-parametric Smoothing and Lack of Fit Tests, Springer Verlag.
4. Hastie T.J. and Tibshirani R.J. (1990): Generalised Additive Models, Chapman & Hall.
5. John Fox (2000): Nonparametric Sample Regression, Sage Publications.
6. Takezawa K. (2005): Introduction to Non-parametric Regression - Wiley Series in Probability and Statistics, John Wiley and Sons.
7. Wand and Jone (1995): Kernel Smoothing, Chapman & Hall.

Practical's on STS558: **Nonparametric Regression**

1. Density Estimation through histogram function for univariate data.
2. Kernel density estimation for univariate data
3. Two dimensional kernel estimator
4. Nadaraya –Watson Kernel Regression estimator .
5. Local polynomial Kernel Regression.
6. Spline smoothing

Soft Core	STS563: Risk and Ruin Models in Insurance	No. of credits : 3

Unit 1

An introduction to nonlife insurance, examples. Utility theory**,** Utility functions, the expected utility criterion. Risk averse and risk loving, risk aversion coefficient, Classes of utility functions.

Principles of premium calculation, expected value principle, principle of zero utility, risk adjusted premium principle. (10 hrs)

Unit 2

Individual risk model for short time, the collective risk model for single period - Compound Poisson distribution, distribution of aggregate claim S, moments of S. The effect of reinsurance, Recursive calculation of aggregate claims distributions, Panjer recursion formula, Extensions of the Panjer recursion formula, The application of recursion formulae, approximate calculation of aggregate claims distributions. (14 hrs)

Unit 3

Ruin theory - Ruin, ruin time, ruin probability. A discrete time risk model, the probability of ultimate ruin, the probability of ruin in finite time, continuous time surplus models, compound Poission process as a model for aggregate claim. The adjustment coefficient, Lunberg inequality. Survival probabilities, Laplace transformation, Approximations of aggregate claims. Surplus below the initial level, the maximal aggregate loss and its distribution. Analysis of reinsurance using ruin theory. (16 hrs)

References

1. David C. M. Dickson (2005) “Insurance Risk and Ruin” Cambridge University Press.
2. Thomas Mikosch (2006), “Non-Life Insurance Mathematics -An Introduction with Stochastic Processes”, Springer.
3. N.L. Bowers, H.U. Gerber, J.C. Hickman, D.A. Jones and C.J. Nesbitt (1997), “Actuarial Mathematics”, Second Edition, The Society of Actuaries.
4. Alexander J. McNeil, Rüdiger Frey, Paul Embrechts (2005), “Quantitative Risk Management: Concepts, Techniques, and Tools”, Princeton University Press.