



NOTIFICATION

Sub: Revised syllabus of M.Sc. Statistics programme.

Ref: Academic Council approval vide agenda

No.: ಎಸಿಸಿ:ಶೈ.ಸಾ.ಸ.4:10 (2022-23) dtd 16.03.2023.

The Revised syllabus of M.Sc. Statistics programme which is approved by the Academic Council at its meeting held on 16.03.2023 is hereby notified for implementation with effect from the academic year 2023-24.

Copy of the Syllabus shall be downloaded from the University Website (www.mangaloreuniversity.ac.in)


REGISTRAR

To,

1. The Chairman, Dept. of Post Graduate Studies and Research in Statistics, Mangalore University, Mangalagangothri.
2. The Chairman, P.G.BOS in Statistics, Dept. of Post Graduate Studies and Research in Statistics, Mangalore University, Mangalagangothri.
3. The Registrar (Evaluation), Mangalore University.
4. The Superintendent (ACC), O/o the Registrar, Mangalore University.
5. The Asst. Registrar (ACC), O/o the Registrar, Mangalore University.
6. The Director, DUIMS, Mangalore University – with a request to publish in the website.
7. Guard File.

M.Sc. (STATISTICS): COURSE STRUCTURE

(with effect from 2023 ADMISSION ONWARDS)

A. Preamble:

In view of the current trend in the subject, the PG Board of Study suggested and incorporated some modifications in the existing syllabus. The present M.Sc. programme under CBCS-PG Scheme has total credits 90 (18 Hard Core Courses of 66 credits + 6 Soft Core Courses with 18 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.

Programme Outcomes (POs)

The curriculum leading to M.Sc-Statistics degree prepares the students for the positions as Data scientists, Data Analyst, and Academicians in Business Intelligence, Information Technology, Software Industry and Government sectors. The curriculum's main objectives are to impart students with an understanding of the various techniques of data analysis, problem solving skills through algorithmic approaches and to prepare them for continued professional development. Upon completion of M.Sc. Statistics degree, students will be able:

- PO 1: To cultivate a statistical attitude and nurture interests in mathematical statistics.
- PO 2: To provide theoretical foundations that will motivate and prepare the students to take up theoretical and applied research in statistics.
- PO 3: To focus on algorithms, designs and advanced softwares to give statistical solutions to real life problems.
- PO 4: To provide first hand practical experience in handling modern statistical software in data analysis
- PO 5: To provide training for a career as statisticians
- PO 6: To train statisticians who can work on challenging problems in various industries.
- PO 7: Communicate effectively, both orally and in writing
- PO 8: Recognize the social and ethical responsibilities of a professional working in the Discipline


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Programme Specific Outcomes (PSO)

On completion of the M.Sc.-Statistics Degree programme the graduates of the M.Sc (Statistics) program will be expected to have to

PSO 1: Professionally inclined Statistics knowledge.

PSO 2: Deeper knowledge of statistical inference and be able to discuss and analyse its possibilities and limitations

PSO 3: Contributions as researchers in theoretical and applied fields of Statistics.

PSO 4: Evince an ability critically, independently, and creatively to identify and formulate problems of significance for statistical science

PSO 5: Have a deeper knowledge of the use of statistical methods in empirical applications, be able to interpret, analyse, and critically evaluate results on the basis of scientific and ethical considerations

PSO 6: Developed the capacity for independent study of statistics and problem-solving at a higher level

B. Course pattern for M.Sc.(Statistics) Programme from 2023-24.

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 2 Practical	4x4=16 2x3=06	22	-	-	-	-	-	-	-	22
II	3 Theory 2 Practical	3x4=12 2x3=06	18	1 Theory	1x3=3	03	1	3	3	-	24
III	2 Theory 2 Practical	2x4=8 2x3=6	14	2 theory	2x3=6	06	1	3	3	-	23
IV	1 theory 1 Practical	1x4=4 1x3=3	07	3 Theory	3x3=9	09	-	-	-	5	21
			61			18			06	5	90


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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: $10 \times 2 = 20$ marks
- (ii) Seminar/Assignment/Viva/ $\therefore$ = 10 marks
Multiple Choice Test etc.

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 contains 8 sub questions. Students will have to answer 6 sub questions each carrying 3 marks.

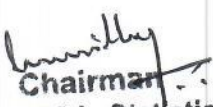
3. Q.No.2 to Q.No.8 will be of long answer type, each carrying 13 marks.

The distribution of marks will be as follows:

$$Q.1 \quad 6 \times 3 = 18$$

$$\text{Any four questions out of remaining 7} \quad 13 \times 4 = 52$$

Total: 70 marks


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First Semester		
STH401	HC	Real Analysis and Matrix Theory
STH402	HC	Probability Theory
STH403	HC	Theory of Sampling
STH404	HC	Distribution Theory
STP405	HC	Practical I: Based on Theory of Sampling
STP406	HC	Practical II: Excel & R-Programming

Second Semester		
STE451	OE(SC)	Statistical Methods
STH452	HC	Design and Analysis of Experiments
STH453	HC	Stochastic Processes
STH454	HC	Theory of Point Estimation
Course Code	SC	Soft Course
STP456	HC	Practical III: Based on STH 452 and STH 453
STP457	HC	Practical IV: Based on STH 454 and Soft Course

Third Semester		
STE501	OE(SC)	Statistical Testing in Data Analysis
STH502	HC	Testing of Hypothesis
STH503	HC	Econometrics
Course Code	SC	Soft Course 1
Course Code	SC	Soft Course 2
STP506	HC	Practical V: Based on STH 502 and Soft Course 1
STP507	HC	Practical VI: Based on STH 503 and Soft Course 2


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Fourth Semester		
STH551	HC	Multivariate Analysis
Course Code	SC	Soft Course 1
Course Code	SC	Soft Course 2
Course Code	SC	Soft Course 3
STP555	HC	Practical VII: Based on all the Theory Papers
STP556	HC	Project Work

Soft Core Courses (3 Credits each)

Second Semester	
STS 455	Operations Research
STS 458	Official Statistics
Third Semester	
STS 504	Actuarial Statistics
STS 505	Time Series Analysis
STS 508	Bayesian Inference
STS 509	Risk and Ruin Models in Insurance
Fourth Semester	
STS 552	Financial Time Series
STS 553	Data Science
STS 554	Survival Analysis
STS 557	Data Mining Techniques
STS 558	Nonparametric Regression
STS 559	Statistical Finance


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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 and Matrix Theory	HC	4	3 hrs.	30	70	100
STH402	Probability Theory	HC	4	3 hrs.	30	70	100
STH403	Theory of Sampling	HC	4	3 hrs.	30	70	100
STH404	Distribution Theory	HC	4	3 hrs.	30	70	100
STP405	Practical I: Based on Theory of Sampling	HC	3	3 hrs.	30	70	100
STP406	Practical II: Excel & R-Programming	HC	3	3 hrs.	30	70	100

II Semester

STH451	Statistical Methods	OE(SC)	3	3 hrs.	30	70	100
STH452	Design and Analysis of Experiments	HC	4	3 hrs.	30	70	100
STH453	Stochastic Processes	HC	4	3 hrs.	30	70	100
STH454	Theory of Point Estimation	HC	4	3 hrs.	30	70	100
Course Code	Soft Course	SC	3	3 hrs.	30	70	100
STP456	Practical III: Based on STH 452 and STH 453	HC	3	3 hrs.	30	70	100
STP457	Practical IV: Based on STH 454 and Soft Course	HC	3	3 hrs.	30	70	100

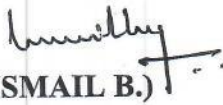

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III Semester

STE501	Statistical Testing in Data Analysis	OE(SC)	3	3 hrs.	30	70	100
STH502	Testing of Hypothesis	HC	4	3 hrs.	30	70	100
STH503	Econometrics	HC	4	3 hrs.	30	70	100
Course Code	Soft Course 1	SC	3	3 hrs.	30	70	100
Course Code	Soft Course 2	SC	3	3 hrs.	30	70	100
STP506	Practical V: Based on STH 502 and Soft Course 1	HC	3	3 hrs.	30	70	100
STP507	Practical VI: Based on STH 503 and Soft Course 2	HC	3	3 hrs.	30	70	100

IV Semester

STH551	Multivariate Analysis	HC	4	3 hrs.	30	70	100
Course Code	Soft Course 1	SC	3	3 hrs.	30	70	100
Course Code	Soft Course 2	SC	3	3 hrs.	30	70	100
Course Code	Soft Course 3	SC	3	3 hrs.	30	70	100
STP555	Practical VII: Based on all the Theory Papers	HC	3	3 hrs.	30	70	100
STP556	Project Work		5	-	30	70	100


(ISMAIL B.)

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Hard Core	STH401: REAL ANALYSIS AND MATRIX THEORY	No. of credits:4
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Course Outcomes:

- CO1: Explain the basics of Real analysis and to apply the acquired knowledge in their subsequent course work.
- CO2: Classify and explain open and closed sets, limit points, convergent and Cauchy convergent sequences, complete spaces, compactness, connectedness, and uniform continuity etc. in a metric space.
- CO3: Know how completeness, continuity and other notions are generalized from the real line to metric spaces.
- CO4: Illustrate the effect of uniform convergence on the limit function with respect to continuity, differentiability and integrability.
- CO5: Determine the Riemann-Stieltjes integrability of a bounded function and prove a selection of theorems and concerning integration.
- CO6: Carry out matrix operations, including inverses and determinants.
- CO7: Demonstrate understanding of the concepts of vector space and subspace.
- CO8: Demonstrate understanding of linear independence, span, and basis
- CO9: Determine eigenvalues and eigenvectors and solve eigenvalue problems.
- CO10: Apply principles of matrix algebra to linear transformations.

Unit I

Review of sequences and series (concepts and statement of theorems without proof) Euclidean space- $\mathbb{R}^n$ - open and closed sets, Bolzano-Weierstrass theorem (statement only), Heine- Borel theorem (statement only), compact sets. Real valued functions, continuous functions, monotonic functions, discontinuities of real valued functions, uniform continuity.

(11 hrs)

Unit II

Sequences of functions - point wise convergence, uniform convergence - Cauchy condition, uniform convergence and differentiation, uniform convergence and integration, uniform convergence of infinite series of functions, Weierstrass M-test, Dirichlet's test, power series and radius of convergence.

(11 hrs)

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Unit III

Riemann Stieltjes' integral - properties, integration by parts, change of variables, step functions as integrators, upper and lower integrals; improper integrals; tests for convergence.

(10 hrs)

Unit IV

Review of basic concepts in vector spaces and algebra of matrices, rank of a matrix, inverse of a matrix, null space and nullity, Generalised inverse of a matrix, Moore- Penrose inverse - computational methods. Linear equation - homogenous and non-homogenous systems, solution space, some theorems on ranks.

(12 hrs)

Unit V

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 hrs)

References:

1. Apostol, T.M. (1996) Mathematical Analysis, Narosa Publishing House, New Delhi, Second Edition.
2. Khuri, A.T. (2002) 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, 2nd 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.
7. Hadley, G.(1990): Linear Algebra, Narosa
8. Rao, C.R. (1973): Linear Statistical Inference and its Applications, second edition, Wiley.
9. Searle S.R.(2017): Matrix Algebra Useful for Statistics, John Wiley & Sons.
10. A. Ramachandra Rao, and P. Bhimasankaram (2000), "Linear Algebra", Hindustan Book Agency.

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Hard Core	STH402: PROBABILITY THEORY	No. of credits: 4
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Course Outcomes:

CO1: Learn to develop complex mathematical reasoning.

CO2: Know the main tools to describe a random variable, such as the probability density function, the cumulative distribution function, and the characteristic function

CO3: Recognize the importance of the central limit theorem and understand when it is appropriate to use normal approximations for the distribution of a statistic.

CO4: Possess techniques of proving theorems and thinking out counter-examples.

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 $\mathbb{R}$. (10 hrs)

Unit II

Measure, probability measure, properties of probability measure, Independence. General distribution functions, Lebesgue and Lebesgue-Stieltjes measures on $\mathbb{R}$. Measurable functions, random variables, induced probability measure and distribution function and properties. Jordan decomposition theorem (without proof) and mixture of probability distributions (12 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. (12 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. (11 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.

(11 hrs)

References:

- 1) Bhat B.R. (1999):Modern 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.
- 11) Bhat, B.R. (2011) Modern Probability Theory, Second edition, Wiley Eastern,


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Hard Core	STH403: THEORY OF SAMPLING	No. of Credits:4
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Course Outcomes:

- CO1: Understand the principles underlying sampling as a means of making inferences about a population
- CO2: Learn the different sampling techniques and able to apply the same in different area and able to analyze data from multi-stage surveys
- CO3: Apply the statistical method to get response in case sensitive matter and able to analyse the data to get accurate results
- CO4: Learn the concepts of ratio and regression method of estimation, estimate the bias and sampling variability and straggles for reducing these
- CO5: Compute the HDI from data ,interpretation of results and understand need, importance of measuring inequality in income and concept of NSS and CSO
- CO6: Understand and solve the practical issues arising in sampling studies

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. (12 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. (12 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, Non sampling errors.

Statistics for National Development: NSO, CSO, Human Development Index, measuring inequality in income: Lorenz Curve, Gini coefficient. (10 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.


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Hard Core	STH404 : DISTRIBUTION THEORY	No. of credits: 4
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Course Outcomes:

- CO1: Apply problem-solving techniques to solving real-world events.
- CO2: Apply selected probability distributions to solve problems.
- CO3: Apply key concepts of probability, including discrete and continuous random
- CO4: Knowledge of probability distributions, conditioning, independence, expectations, and variances.
- CO5: Apply different statistical distributions (e.g., Normal, Binomial, Poisson) and the typical phenomena that each distribution often describes.
- CO6: Applications of Multivariate normal distribution and its properties.

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. (16 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. (13 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. (12 hrs)

Unit IV

Multivariate normal distribution, properties, Characteristic function and its applications. Random sample from Multivariate normal distribution and its properties. Marginal and conditional distribution and properties. Independence of sample mean vector and sample covariance matrix. Wishart distribution-its properties and applications. (15 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) Johnson 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.


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Hard Core	STP405: Practical I: Based on STH403	No. of Credits: 3
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Course Outcomes:

CO1: Learn to determine sample size in various sampling schemes

CO2: Able to apply the unequal probability sampling such as PPSWR and PPSWOR for real life situations.

CO3: Learn to select samples and estimate population parameters using cluster sampling and multistage sampling

CO4: Apply the regression and ratio method estimation for various sampling scheme

CO5: Learn to select samples using Two Phase sampling scheme and estimate the population parameter.

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.

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Hard Core	STP406: Practical II : EXCEL and R- Programming	No. of Credits: 3
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Course Outcomes:

- CO1: Learn the Use graphical tools for data interpretation in R and Excel
- CO2: Understand the R - programming language
- CO3: Develop Macro programming for iterative computing using Excel
- CO4: Develop User defined function using visual basic for different distributions
- CO5: List the probabilities for various continuous and discrete distributions
- CO6: Write and read documents from different environments into R.
- CO7: Understand the use of loops and functions for computations
- CO8: Understand R coding and implementation.
- CO9: Know about debugging tools.
- CO10: Learn to install and use R packages from repositories.

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.)


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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.
10. Generating observations from mixture distributions.


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

CO1: Describe and discuss the key terminology, concepts tools and techniques used in inferential statistics.

CO2: Conduct basic statistical analysis of data.

CO3: Solve a range of problems using the techniques covered.

CO4: Discuss critically the uses and limitations of statistical analysis

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. (13 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. (9 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.)


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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	STH 452: DESIGN AND ANALYSIS OF EXPERIMENTS	No. of credits: 4
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Course Outcomes:

- CO1: Construct and analyze incomplete block designs, Latin square designs and Youden square designs.
- CO2: Identify the effects of different factors and their interactions and analysis of factorial experiments.
- CO3: Construct complete and partially confounded factorial designs and their analysis.
- CO4: Able to analyze the experimental designs with missing values.

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. (13 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). (13 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 (13 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)


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Unit V

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

References:

- 1) Aloke Dey (1986): Theory of Block Designs, Wiley Eastern.
- 2) Angela Dean and Daniel VOSS (2017): Design and Analysis of Experiments, 2nd edition. 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 Kempthorne 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	STH 453: STOCHASTIC PROCESSES	No. of credits: 4
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Course Outcomes:

- CO1: To construct transition matrices for Markov dependent behavior and summarize process information.
- CO2: To learn random walk and gambler's ruin problem; Statistical inference in MC
- CO3: To understand the principles and objectives of model building based on Markov chains, Poisson processes and Brownian motion.
- CO4: To learn Renewal theory and Stationary process
- CO5: To use notions of long-time behavior including transience, recurrence, and equilibrium in applied situations such as branching processes

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. (9 hrs)

Unit II

Stationary distribution, classification of states, transient MC; random walk and gambler's ruin problem; Statistical inference in MC. (10 hrs)

Unit III

Discrete state space continuous time MC: Kolmogorov-Feller 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. (13 hrs)

Unit IV

Renewal theory: Elementary renewal theorem and applications. Statement and uses of key renewal theorem; study of residual life time process. Stationary process: weakly stationary and strongly stationary processes. (12 hrs)


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Unit V

Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Martingale in discrete time, inequality, convergence. (12 hrs)

References:

- 1) A.K. Basu (2003): Introduction to Stochastic Processes, Narosa Publishers.
- 2) Cinlar E. (1975): Introduction to Stochastic Processes, Prentice Hall.
- 3) Ross S.M. (1996): Stochastic Processes 2nd Ed., John Wiley & Sons.
- 4) Bhat B.R. (2004): Stochastic Models: Analysis and Applications, New Age International.
- 5) Karlin S. and Taylor, H.M. (1998): A First Course in Stochastic Processes 3rd Ed., Vol.I, Academic Press.
- 6) Medhi J. (1994): Stochastic Processes 2nd Ed., Wiley Eastern.

Hard Core	STH454: THEORY OF POINT ESTIMATION	No. of credits: 4
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Course Outcome

CO1: To apply various estimation and testing procedures to deal with real life problems.

CO2: To understand Fisher Information, Lower bounds to variance of estimators, MVUE and apply them in practical situations.

CO3: To understand consistency, sufficiency, unbiasedness, CAN and BAN estimators

Unit I

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

Information in data. About the parameters as variation in likelihood 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)

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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. Rohatgi V.K. and A.K.L. Salah (2001): An Introduction to Probability and Mathematical Statistics. Wiley Eastern
5. Silvey S.D. (1970): Statistical Inference. Chapman and Hall.
6. Zacks S. (1981): Parametric Statistical Inference, Pergamon Press.
7. Lehman E.L. (1997): Theory of Point Estimation, John Wiley.
8. Rao C.R. (2009): Linear Statistical Inference and Its Applications 2nd Ed. Wiley Eastern.

Soft Core	STS 455: OPERATIONS RESEARCH	No. of credits: 3
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Course Outcomes:

CO1: To apply the theorems on duality to problems appropriately.

CO2: To explain the concept of complementary slackness and its role in solving primal / dual problem pairs.

CO3: To be able to modify a Primal Problem, and use the Fundamental Insight of Linear Programming to identify the new solution, or use the Dual Simplex Method to restore feasibility.

CO4: To describe the simulation process

CO5: To understand the inventory policies

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.
(10 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

Simulation: Congruential generators, Seeding, Random Number Generation- Basic principles of Random number generation, Inversion method, Accept-reject method. Resampling Techniques - Gibbs sampler, Bootstrap sampling, Markov Chain Monte Carlo(MCMC) method.
(12 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)


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References:

1. D.Gross and C.M.Harris (1985): Fundamentals of Queuing Theory, 2nd Ed., John
2. Wiley.
3. G. Hadley (1975): Linear Programming, Addison Wesley.
4. Katta G. Murthy (1976): Linear and Combinatorial Programming, John Wiley &
5. Sons.
6. N.S. Kambo (1991): Mathematical Programming Techniques, Affiliated East-West
7. Press.
8. H. A. Taha (2007): Operations Research – An Introduction (8th Edition), Prentice-
9. Hall, India.
10. B.D. Sivazlian and L.E. Stanfel (1975): Analysis of Systems in Operations Research,
11. Prentice-Hall.
12. H.G.Daeallenbach & John A.George(1978): Introduction to Operations Research
13. Techniques, Allyn & BaconInc.
14. S. D. Sharma(2012) : Operations Research Theory Methods & Applications.

Soft Core	STS 458: OFFICIAL STATISTICS	No. of credits : 3
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Course Outcomes:

CO1: Understanding the functioning of official statistics.

CO2: Search, evaluation and use of metadata and ability to judge the quality of data on this basis

CO3: Give exposure to Population growth in developed and developing countries and its challenges

CO4: To familiar with the Statistics related to society

Unit I

Introduction to Indian and International statistical systems. Role, function and activities of Central and State statistical organizations. Organization of large scale sample surveys. Role of National Sample Survey Organization. General and special data dissemination systems.

(10 hrs)

Unit II

Population growth in developed and developing countries, evaluation of performance of family welfare programmes, projections of labour force and manpower. Scope and content of population census of India.

(10 hrs)

Unit III

System of collection of Agricultural Statistics. Crop forecasting and estimation, productivity, fragmentation of holdings, support prices, buffer stocks, impact of irrigation projects. (10 hrs)

Unit IV

Statistics related to industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

(10 hrs)

REFERENCE:

1. Basic Statistics Relating to the Indian Economy (CSO) 1990.
2. Guide to Official Statistics (CSO) 1999.
3. Statistical System in India (CSO) 1995.
4. Principles and accommodation of National Population Censuses, UNESCO.
5. Panse, V. G., Estimation of Crop Yields (FAO).
6. Family Welfare Yearbook. Annual Publication of D/o Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt

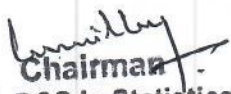
Hard Core	STP 456:Practical III: Practicals based STH 452 and STH 453	No. of credits: 3
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Course Outcomes:

- CO1: To learn parametric, non-parametric and testing (simple, as well as, composite procedures.
- CO2: To learn a strong theoretical background to develop test procedures for any type of populations
- CO3: To demonstrate computational skills to implement various statistical inferential approaches.
- CO4: Implement the multivariate analysis techniques with statistical software such as R in a manner that the methodology adopted is motivated by appropriate statistical theory.
- CO5: To familiarize the students with the stochastic processes.
- CO6: To familiarize the students with the applications of stochastic methods in practical situations.

Practicals on STH 452: 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


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Practicals on STH 453: Stochastic Processes

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

Hard Core	STP457: Practicals IV: Based on STH 454 and Soft Course	No. of credits:3
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Course Outcomes:

CO1: To carry out method of scoring and to fit the truncated distributions

CO2: To solve the problems related to linear programming

Practical Based on STH454: THEORY OF POINT ESTIMATION

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

Practical Based on STS 455: OPERATIONS RESEARCH

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

Open Elective	STE501 : STATISTICAL TESTING IN DATA ANALYSIS	No. of credits: 3
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Course Outcomes:

CO1: Demonstrate their knowledge of the basics of inferential statistics by making valid generalizations from sample data

CO2: Perform Test of Hypothesis as well as calculate confidence interval for a population parameter for single sample and two sample cases. Understand the concept of p-values.

CO3: Learn non-parametric test such as the Chi-Square test for Independence as well as Goodness of Fit.

CO4: Compute and interpret the results of Bivariate and Multivariate Regression and Correlation Analysis, for forecasting and also perform ANOVA and F-test.

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 hrs)

Unit II

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.

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. (16 hrs)

Unit III

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
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Course Outcomes:

CO1: To learn the basics of testing of hypothesis and understand MP and UMP tests.

CO2: To learn Non-existence of UMP test and unbiased test

CO3: To learn to construct confidence intervals for population parameters based on various statistical methods.

CO4: To understand LRT test and large sample tests.

CO5: To familiarize the concepts of non parametric tests

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. (14 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. (10 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. (12 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	STH 503: ECONOMETRICS	No. of credits: 4
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Course Outcomes:

CO1: A broad knowledge of regression analysis relevant for analyzing economic data.

CO2: Learn estimation of model parameters, inference problems in case of simple and multiple linear regression model

CO3: estimate the model parameters of regression model when some of the basic ideal conditions are violated

CO4: regression model adapted to cross section and time-series data

CO5: Learn to select the best subsets of regressors for the model.

CO6: Learn how to use estimated regression models for prediction.

CO7: Understand the estimation techniques and inference procedure in case of simultaneous equations model

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.

(13 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.

(11 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	STS 504: ACTUARIAL STATISTICS	No. of credits: 3
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Course Outcomes:

CO1: To understand how actuarial science is used in finance, investments, banking and insurance.

CO2: Explain the concept of survival models

CO3: Describe estimation procedures for lifetime distributions.

CO4: To understand the statistical behaviour of actuarial indicators

CO5: To solve the problems related to the benefit amounts in insurance, annuities, premiums and reserves.

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 II

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/mthly 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 III

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. (14 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

Soft Core	STS 505: TIME SERIES ANALYSIS	No. of credits : 3
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Course Outcomes:

- CO1: Understand the concept of time series and its components
- CO2: Understand the bases of different models of time series analysis including decomposition
- CO3: To learn proper model identification and its estimation.
- CO4: To learn several ways of identifying the forecasting methods with the least forecasting error.

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. (10 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. (10hrs)

References:

1. Box GEP and Jenkins G.M. (1976): Time Series Analysis: Forecasting and Control, Holden-day, San Francisco.
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. Montgomery 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
9. Shumway, R. H and Stoffer, D. S. (2016). Time series Analysis and its Applications, 4th edition. Springer.

Hard Core	STP 506: Practical V: Based on STH502 and Soft Course 1	No. of credits: 3
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Course Outcomes:

CO1: Construct complete and partially confounded factorial designs and their analysis.

CO2: Able to analyse the experimental designs with missing values.

CO3: A running knowledge of R in the estimation techniques in the other applied areas.

CO4: To construct life tables

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 Smirnov 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 Smirnov test.

Practicals on STH504: 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.

Hard Core	STP 507:Practical V: Based on STH503 and Soft Course 2	No. of credits: 3
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Course Outcomes:

- CO1: Learn estimation of model parameters, inference problems in case of simple and multiple linear regression model
- CO2: Estimate the model parameters of regression model when some of the basic ideal conditions are violated
- CO3: Learn to select the best subsets of regressors for the model.
- CO4: Learn how to use estimated regression models for prediction.
- CO5: Understand the estimation techniques and inference procedure in case of simultaneous equations model
- CO6: Interpretation and critical evaluation of the outcomes of empirical analysis
- CO7: Determine how and when to apply different methods of time series analysis and how to test for goodness of fit using the R software coding and in built packages.
- CO8: To forecast the time series with specific components using stationary methods, trend methods, and seasonal methods.

Practicals based on STH 503: 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.

Practicals on STS505: Time Series Analysis

1. Estimation and elimination of trend component: finite Moving Average method and Variate difference method.
2. Estimation and elimination of trend and 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.

Soft Core	STS 508 : BAYESIAN INFERENCE	No. of credits : 3
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Course Outcomes:

- CO1: Explain in detail the Bayesian framework for data analysis and its flexibility and be able to demonstrate when the Bayesian approach can be beneficial.
- CO2: Develop, analytically describe, and implement both single and multi parameter probability models in the Bayesian framework.
- CO3: Demonstrate the role of the prior distribution in Bayesian inference and be able to articulate the usage of non-informative priors and conjugate priors.
- CO4: Show high level Interpretation of Bayesian Analysis Results and be able to readily perform Bayesian model evaluation and assessment.
- CO5: Demonstrate the necessary skills to: fit hierarchical models, provide thorough technical specifications for these models.
- CO6: Perform Bayesian computation using Markov chain Monte Carlo methods

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. (11 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. (11 hrs)

References:

1. Bernardo 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, McGraw 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.

Hard Core	STH 551: MULTIVARIATE ANALYSIS	No. of credits: 4
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Course Outcomes:

- CO1: Use multivariate distributions and analysis techniques appropriately
- CO2: Undertake multivariate hypothesis tests, and draw appropriate conclusions.
- CO3: Analyze multivariate data, dimension reduction and the dependence structure of variables to extract the useful information from multivariate dataset
- CO4: Apply suitable tools for classification to formulate and solve real-life problems.
- CO5: Apply suitable tools for exploratory data analysis and clustering techniques to extract the useful information from real-life problems.

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.

(12hrs)

Unit II

Confidence regions, simultaneous confidence statements. Independence of subvectors, sphericity test. Test for covariance matrices (Statistics and their distributions- Statements only and applications), MANOVA

Cluster Analysis: distances and similarity measures, hierarchical clustering methods, K – means method.

(10 hrs)

Unit III

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.

(12hrs)

Unit IV

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.

(12 hrs)

Unit V

Factor Analysis: orthogonal factor model, factor loadings, estimation of factor loadings, factor scores. Introduction to structural equation modeling (SEM) – nature, purpose, variables, scales, construct validity, mediation effect and goodness of fit measures of SEM model

(10 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 (2012) Applied Multivariate Statistical Analysis, Prentice Hall, 6th edition
7. Alvin C. Rencher, William F. Christensen (2012), "Methods of Multivariate Analysis" John Wiley.
8. Rex B kline (2015) : Principles and practices of structural equation modeling , fourth edition ,Guildford press.
9. Geoffrey,M,Maruyama (1998): Basics of structural equation modelling ,Sage Publications ,Inc.
10. A. M. Mathai. Hans, J. Haubold, and Serge B.Provost (2022) Multivariate Statistical Analysis in the Real and Complex Domains. Springer.

• Soft Core	STS 552 : FINANCIAL TIME SERIES	No. of credits: 3
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Course Outcomes:

- CO1: The ability to approach and analyse financial time series
CO2: The ability to differentiate between various financial time series models.
CO3: The ability to perform cross-validation of the model developed.
CO4: The ability to forecast future observations of the market.
CO5: A running knowledge of R for applied time series analysis

Unit 1

Financial time series and their characteristics: Assets and Markets, Asset Returns, dividends- definition, types and policies. Distribution of returns, empirical properties of returns, Market Indexes. (10 hrs)

Unit II

Unit root non-stationarity:-random walk, random walk with drift and trend stationary. Testing for unit roots: Dickey-Fuller Tests and its extension, PP and KPSS test statistics. Unit Roots in Time Series Models- Unit Roots in Autoregressions, Unit Roots in Moving Averages. Regression Models with Time Series Errors.Cointegration. Test for Cointegration, Error Correction Models. (13 hrs)

Unit III

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 IV

The GARCH model and properties. Estimation and forecasting, limitations of GARCH model, Elementary properties of EGARCH and M-GARCH models. (09 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 Gouriéroux 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.

Soft Core	STS 553 : DATA SCIENCE	No. of credits: 3
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Course Outcomes:

- CO1: Develop in depth understanding of the key technologies in data science.
- CO2: Understand the theory of certain Statistical method of data Science.
- CO3: Gain practical, hands-on experience with statistics programming languages and big data tools through coursework.
- CO4: Demonstrate knowledge of statistical data analysis techniques utilized in company decision making.
- CO4: Apply principles of Data Science to the analysis of real-life data. .
- CO5: Employ cutting edge tools and technologies to analyze data of Data Science Apply algorithms to build machine intelligence.

Unit I

Introduction to data science, and its product, data science environment/ecosystem. Data visualization - data graphics, elements of visual perception, data manipulation -SQL, merging, aggregating and iterating. (12 hrs)

Unit II

Data preparation - data cleaning, methodologies and its validation. Python/R Data preparation and applications. (8hrs)

Unit III

Machine learning Methods: Bayes model and residual error, linear methods, nearest neighbourhood methods and support vector machines. Neural network, artificial intelligence. Model selection and Evaluation. (12 hrs)

Unit IV

Random Forests - Bias variance decomposition, regression, classification, randomised models Multi-model data processing- components and applications. (10 hrs)

A mini project on data science by self study (for internal evaluation only).

Reference:

1. Richard O Duda, Peter E Hart, and David D Stork (2012): Pattern Classification, John Wiely and Sons
2. Oswald Campesato (2020): Artificial Intelligence Machine Learning and Deep Learning, Mercury Learning And Information, New Delhi
3. Charles Elkan (2013) Predictive analytics and data mining -e-book
4. Trevor Hastie, Robert Tibshirani& Jerome Friedman (2001): The Elements of Statistical Learning: Data Mining, Inference and Prediction, Springer, New York.
5. James D. Miller (2017): Statistics for Data Science, Packt Publishing Ltd.
6. Wes McKinney(2018): Python for Data Analysis, O'Reilly Media, Inc.

Soft Core	STS 554: SURVIVAL ANALYSIS	No. of credits: 3
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Course Outcomes:

- CO1: To Identify characteristics of survival data and their implications for analysis
- CO2: To Perform and interpret univariate analyses of survival data
- CO3: To Compare groups using common statistical procedures
- CO4: To analyze survival data and interpret results using Cox proportional hazards model
- CO5: To Assess models for fulfilment of proportional hazards & other aspects of model adequacy

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. Kalbfleisch 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	STS 557 : DATA MINING TECHNIQUES	No. of credits :3
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Course Outcomes:

- CO1: Design data warehouse with dimensional modelling and apply OLAP operations.
- CO2: Gain knowledge about basic concepts of Machine Learning and Identify machine learning techniques suitable for a given problem
- CO3: Compare and evaluate different data mining techniques like classification, prediction, clustering and association rule mining
- CO4: Apply Dimensionality reduction techniques.
- CO5: To assess the strengths and weaknesses of the different algorithms, identify the application area of algorithms and apply them.
- CO6: Apply data mining techniques as well as methods in integrating and interpreting the data sets and improving effectiveness, efficiency and quality for data analysis.

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 of 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)

Hard Core	STP 555: Practical VII: Based on all the Theory Papers	No. of credits: 3
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Practicals on STH 551: MULTIVARIATE ANALYSIS

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

Practicals on STS 552: FINANCIAL TIME SERIES

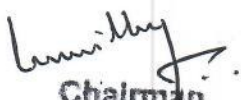
1. Plot of financial time series and examining the features of the series
2. ACF and PACF of Return series and squared Return series
3. Dickey Fuller Unit Root Test, Co-integration and error correction models
4. Fitting ARCH model
5. Fitting GARCH Model
6. Residual Analysis and Diagnostic Checking

Practicals on STS 553: DATA SCIENCE

1. Data preparation and validation.
2. Neural network: model selection and evaluation.
3. Bayesian classifier, SVM and k-NN classifier.
4. Random Forest.

Practicals on STS 554: SURVIVAL ANALYSIS

1. Cox proportional hazard model
2. Kaplan Meir Estimator and Greenwood's s Formula
3. Computation of failure rate and mean residual life
4. Accelerated failure model (any two distributions)


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

- CO1: To understand nature and scope of nonparametric regression
CO2: To learn kernel approaches to density estimation and regression
CO3: Ability to apply spline and basis approaches and its computational issues
CO4: An insight into asymptotic properties different methods
CO5: To introduce generalised additive models

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. (12 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. (12 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.

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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	STS 559 : STATISTICAL FINANCE	No. of credits: 3
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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 Edition.
3. John C. Hull (2008) *"Options, Futures and other derivatives"*, Pearson Education India.

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 Jones (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


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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.


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List of Textbook added/ changed to new addition

Following Text books are added to probability theory reference part

1. Bhat, B.R. (2011) Modern Probability Theory, Second edition, Wiley Eastern,

Following Text book are added to Time Series Analysis reference part

1. Shumway, R. H and Stoffer, D. S. (2016). Time series Analysis and its Applications, 4th edition. Springer.

Following Text book's edition are changed

STH 452: Design and Analysis of Experiments reference part

1. Angela Dean and Daniel VOSS (2017): Design and Analysis of Experiments, 2nd edition. Springer.

STH 401: REAL ANALYSIS AND MATRIX THEORY

1. Khuri, A.T. (2002) Advanced Calculus with Applications in Statistics, John Wiley & Sons, Inc.,
2. Hadley, G.(1990): Linear Algebra, Narosa
3. Searle S.R.(2017): Matrix Algebra Useful for Statistics, John Wiley & Sons.

STH 453: STOCHASTIC PROCESSES

1. Ross S.M.(1996): Stochastic Processes 2nd Ed., John Wiley & Sons.
2. Bhat B.R. (2004): Stochastic Models: Analysis and Applications, New Age International.
3. Karlin S. and Taylor, H.M. (1998): A First Course in Stochastic Processes 3rd Ed., Vol.I, Academic Press.
4. Medhi J. (1994): Stochastic Processes 2nd Ed., Wiley Eastern.

STH 454: THEORY OF POINT ESTIMATION

1. Lehman E.L. (1997): Theory of Point Estimation, John Wiley.
Rao C.R. (2009): Linear Statistical Inference and Its Applications 2nd Ed. Wiley Eastern.

STH 551: MULTIVARIATE ANALYSIS

1. A. M. Mathai. Hans, J. Haubold, and Serge B.Provost (2022) Multivariate Statistical Analysis in the Real and Complex Domains. Springer.


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