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UNIVERSITY OF CALICUT

Abstract

General and Academic IV - Faculty of Science - Revised scheme and syllabus of M.Sc Statistics programme (CCSS), in accordance with the Regulations for CCSS in the University Teaching Departments with Multiple entry and exit options (2024), w.e.f 2024 admission onwards - Approved - Orders Issued

G & A - IV - K Section

U.O.No. 9796/2025/Admn Dated, Calicut University.P.O, 04.07.2025

Read:-1. U.O.No. 14520/2024/Admn dated 25/09/2024
2. U.O.No. 5258/2025/Admn dated 27/03/2025
3. Remarks from Chairperson, Board of Studies in Statistics(PG)
4. Approval of the Dean, Faculty of Science dated 26/06/2025

ORDER

1. The Scheme and Syllabus for M.Sc Statistics programme (CCSS) in line with the Regulations for (CCSS) in the University Teaching Departments, with multiple entry and exit options (2024), have been implemented effective from the 2024 admissions in the University of Calicut, vide paper read (1) above.

2. As per the reference cited (2),sanction has been accorded to implement the CCSS PG Academic Committee's meeting resolutions, including amendments to Clause 19.3 (course semester number: 01–10) and Clause 13.3 Table 2 (adding that General Foundation Courses like AEC/SEC/VAC/MDC fall under academic level 100–199).

3. The Chairperson, Board of Studies in Statistics (PG) forwarded the revised version of the syllabus of M.Sc Statistics programme (CCSS) in line with the Regulations for (CCSS) in the University Teaching Departments, approved by the PG Board of Studies.

4. The Dean, Faculty of Science, as per paper (4) referenced above, approved the revised version of the syllabus of M.Sc. Statistics programme (CCSS), in line with the Regulations for (CCSS) in the University Teaching Departments with multiple entry and exit options effective from the 2024 admissions as recommended and forwarded by the Chairperson, BoS in Statistics (PG).

5. Considering the matter in detail, the Vice-Chancellor has approved the revised syllabus of M.Sc Statistics programme (CCSS), which incorporates the necessary modifications and aligns with the regulations for multiple entry and exit options for 2024 admissions.

6. Therefore, the revised scheme and syllabus for the M.Sc Statistics programme (CCSS) in the University Teaching Departments with multiple entry and exit options with effect from 2024 admission,are implemented, u/s 10(13) of CU Act 1975.

7. Orders are issued accordingly. (Syllabus appended)

Ajayakumar T.K

Assistant Registrar

To

The Head, Department of Statistics

Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/JCE VIII/DoA/EX and EG Sections/GA I F/ DOA/CHMK Library/SUVEGA/SF/DF/FC

Forwarded / By Order

Section Officer

M.Sc. Statistics Programme under CCSS
at the Department of Statistics, University of Calicut

(Under the Regulations for Choice-based Credit Semester System in the University Teaching Departments with multiple entry and exit options (2024))

Programme Structure & Syllabi
(With effect from the academic year 2024-25 onwards)

Duration of programme: **Two years -** divided into **Four semesters** of not less than **90** working days each.

Course Code	Type	Course Title		Credits	Lecture/ Tutorial/ Practical hours	Total Marks-100	
						CE	ES
I SEMESTER(Total Credits: 24)							
STA07C501	DSC	Mathematical Methods for Statistics		4	3-0-2	50	50
STA07C502	DSC	Distribution Theory		4	3-0-2	50	50
STA07C503	DSC	Introduction to Probability Theory		4	4-0-0	50	50
STA07E5--	DSE	Elective-I*	**Elective should be taken from STA07E501– STA07E505*	4	3-0-2 or 4-0-0	50	50
STA07E5--	DSE	Elective-II** (Open Elective)	***Elective (open) should be taken from STA07E506 –STA07E507*	4	3-0-2 or 4-0-0	50	50
STA07M5--	Online/MOOC-I	Will be decided by the Department Council		4			---
II SEMESTER(Total Credits: 20)							
STA08C501	DSC	Sampling Methods		4	3-0-2	50	50
STA08C502	DSC	Theory of Estimation		4	3-0-2	50	50
STA08C503	DSC	Testing of Statistical Hypotheses		4	3-0-2	50	50
STA08E5--	DSE	Elective-III***	****Elective should be taken from STA08E501– STA08E505*	4	3-0-2 or 4-0-0	50	50
STA08M5--	Online/MOOC-II	*Will be decided by the Department Council*		4		---	---
III SEMESTER(Total Credits: 20)							
STA09C601	DSC	Stochastic Processes		4	3-0-2	50	50
STA09C602	DSC	Design and Analysis of Experiments		4	3-0-2	50	50
STA09C603	DSC	Multivariate Analysis		4	3-0-2	50	50
STA09E6--	DSE	Elective-IV****	*****Electives should be taken from STA09E601- STA09E611*	4	3-0-2 or 4-0-0	50	50
STA09E6--	DSE	Elective-V****		4	3-0-2 or 4-0-0	50	50
IV SEMESTER(Total Credits: 24)							
STA10C601	DSC	Time Series Analysis		4	3-0-2	50	50
STA10C602	DSC	Regression Methods		4	3-0-2	50	50
STA10C603	*#OR STA10P601* DSC	Advanced Probability Theory#	# Or Project and Dissertation of 12 credits	4	4-0-0	50	50 STA10P601 - 100 (ES)
STA10C604	DSC	Modern Statistical Inference#		4	3-0-2	50	50
STA10C605	DSC	Advanced Trends in Statistics#		4	4-0-0	50	50
STA10M6--	Online/MOOC-III	*Will be decided by the Department Council*		4		---	---

[Total Credits: 88(DSC-56, DSE-20, MOOC-12)]

LIST OF ELECTIVES

Sl. No.	Course Title		Credits	Lecture Tutorial/ Practical hours
STA07E501	Operations Research		4	3-0-2
STA07E502	Official Statistics		4	4-0-0
STA07E503	Measure and Mathematical Analysis		4	4-0-0
STA07E504	Demographic Techniques		4	3-0-2
STA07E505	Computer Oriented Statistical Methods		4	3-0-2
STA07E506	Statistical Techniques for Data Analysis	Open Electives	4	3-0-2
STA07E507	Topics in Probability		4	4-0-0
STA08E501	Actuarial Statistics		4	4-0-0
STA08E502	Order Statistics		4	4-0-0
STA08E503	Data Mining Techniques		4	4-0-0
STA08E504	Statistical Quality Control		4	3-0-2
STA08E505	Analysis of Clinical Trials		4	3-0-2
STA09E601	Models and Methods for Lifetime Data		4	3-0-2
STA09E602	Statistical Decision Theory		4	3-0-2
STA09E603	Machine Learning Models and Applications		4	3-0-2
STA09E604	Econometric Models		4	3-0-2
STA09E605	Analysis of Longitudinal Data		4	3-0-2
STA09E606	Risk Modeling and Survival Analysis		4	3-0-2
STA09E607	Spatial Statistics		4	3-0-2
STA09E608	Biostatistics		4	3-0-2
STA09E609	Statistical Analysis of Categorical Data		4	3-0-2
STA09E610	Advanced Operations Research		4	3-0-2
STA09E611	Applied Multivariate Methods		4	3-0-2

Objectives of the Programme

The present programme is intended to provide a platform for prospective students to undergo higher studies in the subject as well as to train them to suit for the needs of the society. Apart from learning discipline specific core Statistics subjects, the students can choose electives depending upon their interests, under the choice based credit system. The students are also trained to handle real life problems through the practical classes and project work. As a part of the course the students are also exposed to various statistical software such as SPSS, MATLAB, PYTHON and R.

Programme Outcomes

PO-11: Research and Inquiry:

- The capacity to develop, design, conduct, and evaluate research
- Demonstrating the ability to apply appropriate research methodologies and techniques to generate original and meaningful knowledge.
- Capacity to develop appropriate use of statistical and other analytical tools and techniques to execute and report the results of an experiment or investigation

PO-12: Innovation and Creativity:

- Apply critical thinking, creativity, and innovation to identify and solve problems
- Develop new ideas, and make original contributions to their field and solve interdisciplinary problems.

PO-13: Professionalism and Ethics:

- Exercise professional judgment, ethical conduct, and social responsibility in their work
- Proper interactions, demonstrating awareness of the ethical implications of their research and professional practice.

PO-14: Social responsibility:

- Develop social responsibility in their work.
- Participate in actions to address environmental and sustainable development issues
- Proper interactions and act with integrity and develop the ability to communicate scientific information and ideas effectively to a wide range of audiences, including policymakers, the public, and non-specialists.

  They may also demonstrate the ability to translate scientific knowledge into practical applications that benefit society.

Programme Specific Outcomes:

On successful completion of the programme, the post graduates will be able to achieve the following outcomes:

PSO-1: Gain comprehensive knowledge and understanding of basic concepts in statistics and its linkages with other scientific disciplines and be able to apply the concepts of Statistics for solving real life problems;

PSO-2: Acquire skills and competencies in statistical computing methods and develop algorithms and computer programmes for analyzing complex/big data sets as required for employment in government and private sectors:

PSO-3: Will identify interdisciplinary applications of Statistics for enhancing career prospects in different fields and research areas and communicate effectively complex statistical ideas to people working in diverse spheres of academics and organizational set ups;

PSO-4: Become professionally inclined statistics teachers/statistician/data scientist who have sound knowledge of the subject matter and specialize in knowledge discovery through statistical methods;

PSO-5: Make unique contribution for the development of discipline and the domain of human knowledge through the use of empirical data by using scientific approaches, addressing complex and challenging problems in emerging areas of the discipline;

PSO-6: Acquire enough knowledge of the basic theoretical and applied ideas of statistics to pursue a Ph.D. or begin a career as an applied statistician while adhering to the highest ethical standards in the statistical sciences.

PO –PSO Mapping

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
PO11	2	3	1	1	3	3
PO12	1	1	2	3	3	1
PO13	1	1	2	3	2	3
PO14	1	2	3	2	2	2

3- High alignment, **2-** Moderate alignment, **1-**Low alignment

DETAILED SYLLABUS

STA07C501: Mathematical Methods for Statistics (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Solve problems on uniform convergence of sequence and series of functions.
CO2: Illustrate vector space, subspaces, independence of vectors, basis and dimension, with examples.
CO3: Solve systems of linear equations, diagonalize matrices and classify quadratic forms.
CO4: Compute g-inverse of matrices, algebraic and geometric multiplicity of characteristic roots.
CO5: Compute the limit, continuity and optima of multivariable functions.
CO6: Develop skills in writing programs for solving problems in matrices and vectors.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓				✓
CO2	✓	✓	✓			✓
CO3	✓	✓	✓			✓
CO4	✓	✓	✓			✓
CO5	✓	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Sequences and Series of Functions - Point wise convergence of sequence of functions. Examples of sequences of real valued functions. Definition of Uniform convergence. Uniform convergence and continuity. Cauchy condition for uniform convergence. Uniform convergence of infinite series of functions. Uniform convergence and Riemann-Stieltjes Integration. Uniform convergence and differentiation.

Unit-II. Algebra of vectors - Vector spaces (definition and examples). Subspaces. Linear independence. Basis and dimension. Linear equations. Vector spaces with an inner product: Properties. Gram-Schmidt orthogonalization. Orthogonal projection of a vector.

Unit-III. Algebra of matrices- Theory of matrices and determinants: Matrix operations. Elementary matrices and diagonal reduction of a matrix. Determinants. Transformations. Generalized inverse of a matrix. Matrix representations of vector spaces, bases, etc. Idempotent matrices. Special products of matrices.Eigen values and reduction of matrices: Classification and transformations of quadratic forms. Roots of determinantal equations. Canonical reduction of matrices. Projection operator.

Unit-IV. Multivariable functions - Limit and continuity of multivariable functions (Definitions, Statement of theorems and problems). Derivatives. Directional derivatives and continuity. Total derivative in terms of partial derivatives. Taylor's theorem.Inverse and implicit functions theorems (Statement and examples).Optima of multivariable functions (Concepts and problems).

(*Practical using R/Python software of the contents of this course)*

Text Books

1. S. C.Malik and Savita Arora (2022). Mathematical Analysis. Sixth Edition. New Age International Limited, New- Delhi.
2. Apostol, T.M. (1974). Mathematical Analysis -Second Edition. Narosa Publishing House, New-Delhi. Reprint 1985
3. Khuri, A. T. (1993). Advanced Calculus with Applications in Statistics. John Wiley & Sons, NewYork.
4. Rao, C.R. (2002). Linear Statistical Inference & Its Applications- Second Edition. John Wiley &Sons, New York.

References

1. Rao,A.R. and Bhimsankaram, P. (1992). Linear Algebra. Tata McGraw Hill, New Delhi.
2. Lewis, D.W. (1996). Matrix Theory. Allied Publishers, Bangalore.
3. Graybill, F. A. (1983). Matrices with Applications in Statistics. John Wiley & Sons, New York.

STA07C502: Distribution Theory (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Distinguish different discrete distributions and illustrate their role in modeling count data.

CO2: Explain Pearson system and its different members and how they arise from the defining differential equation.

CO3: Describe different positive valued and real valued random variables along with their properties and role in modeling real life data

CO4: Find marginal and conditional distributions, explain distribution of functions of random vectors, order statistics and their distributions.

CO5: Explain sampling distributions- t, Chi-square and F and their applications.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓	✓	

COURSE CONTENTS

Unit-1: Discrete distributions - Bernoulli, Discrete Uniform, Binomial, Negative Binomial, Geometric, Hyper geometric, Poisson Logarithmic Series and multinomial distributions. Power series distribution and their properties.

Unit-II. Continuous distributions - Systems of Distributions- Pearson system and Transformed Distributions. Uniform, Exponential, Gamma, Beta, Cauchy, Normal, Pareto, Weibull, Laplace, lognormal distributions. Bivariate Normal Distributions and their properties.

Unit-III. Notion of vector of random variables. Distribution function marginal and joint distributions in the i.i.d. case. Functions of Random Vectors. Order Statistics and their Distributions.

Unit-IV. Sample moments and their distributions- Sample characteristics and their distributions, Chi-Square, t and F distributions (Central and Non-Central). Applications of Chi-square, t and F.

(Practical using R/Python software of the contents of this course)

Text Books

1. Rohatgi V. K. and A. K. Md. E. Saleh (2001). An Introduction to Probability and Statistics. John Wiley & Sons, New York.
2. Krishnamoorthy, K. (2016). Hand book of Statistical Distributions with Applications. Chapman & Hall, New York.
3. Rohatgi, V.K. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley & Sons, New York

4. ParimalMukhopadhyay (2016). Mathematical Statistics. Third Edition. Kolkata Books and Allied (P) Ltd.

References

1. Johnson, N.L., Kotz. S. and Balakrishnan, N.(2004). Continuous Univariate Distributions-Vol. I-Second Edition. John Wiley &Sons, New York.
2. Johnson, N.L., Kemp, A.W. and Kotz. S. (2005). Univariate Discrete Distributions. John Wiley & Sons, New York.

STA07C503: Introduction to Probability Theory (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Describe the sets and classes of sets, the concepts of probability measure, random variables, and of distribution functions.

CO2: Compute the expectation of simple, non-negative and arbitrary random variables.

CO3: Develop different types of inequalities such as Cr-inequality, Basic inequality, etc.

CO4: Illustrate the convergence of sequence of random variables with examples.

CO5: Discuss independence of events, BorelCantelli Lemma, Borel and Kolmogrov zero-one criteria.

CO6: Describe the properties of characteristic function and the inversion theorem.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		✓
CO2	✓		✓	✓		✓
CO3	✓		✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓		✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Sets and Classes of events- Sequence of sets and limits, field, sigma-field, minimal sigma field, monotone field. Random variable- Concepts of functions and inverse functions. Definitions and examples of random variables. Limits of random variables- sigma field induced by a sequence of random variables and limits of random variables. Definitions of probability space and induced probability space. Distribution function. Decomposition ofdistribution function. Vector valued random variables and its distribution function.

Unit-II. Mathematical expectation of simple, non-negative and arbitrary random variables - Properties of expectation. Inequalities and moments- moment generating functions, $C_r$inequality, Holder's inequality, Jenson's inequality, Basic inequality, Markov inequality.

Unit-III. Convergence of random variables- Convergence in probability, convergence almost surely, convergence in distribution, convergence in r^{th}mean, and their mutual implications.

Unit-IV. Characteristic function- Definition and simple properties, Statement of Inversion formula moments, Bochner's theorem. Statement of dependence of events, classes of events. Independence of random variables, Kolmogorow 0-1 law, Borel 0-1 criterion. Borel-Cantelli Lemma.

Text Books

1. Bhat, B.R. (2024).Modern Probability Theory-: An introductory text book. Fifth Edition. New-Age International, NewDelhi.

References

1. Laha, R.G. and Rohatgi, V.K. (2000). Probability Theory. Dover Publications Inc., New York.
2. Rohatgi V. K. and A. K. Md. E. Saleh (2001). An Introduction to Probability and Statistics. John Wiley& Sons , New York.

STA08C501: Sampling Methods (4 credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Classify various sampling methods as probability sampling and non-probability sampling.

CO2: Compare the performance of the estimation methods for population mean, total and proportion under various sampling schemes.

CO3: Apply various sampling procedures like SRS, stratified, systematic, cluster etc., and estimate then population parameters for attributes and variables.

CO4: Describe the use of auxiliary information for the estimation of population characteristics using ratio,product and regression estimators.

CO5: Analyze data under varying probability sampling and from multi-stage and multiphase surveys.

CO6: Explain various types of errors in surveys, and procedures to rectify them.

CO7: Develop skills in writing programs for handling practical issues arising in sampling studies.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		✓
CO2	✓			✓		✓
CO3	✓	✓		✓	✓	
CO4	✓			✓	✓	
CO5	✓	✓	✓	✓		
CO6	✓			✓	✓	
CO7		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Census, Sampling, Probability and non-Probability sampling. SRSWOR and SRSWR. Estimation of population mean. Population total and population proportion. Variance of the estimates and standard error. Estimation of sample size. Stratified random sampling. Allocation problem. Various allocations. Construction of strata.

Unit-II. PPS sampling with and without replacement. Estimation of population mean, total and variance in PPS sampling with replacement. Desraj's ordered estimator. Murthy's unordered estimator. Horvitz – Thomson estimator. Their variances and standard error. Yates – Grundy estimator. Sen – Midzuno scheme of sampling. ΠPS sampling.

Unit-III. Ratio estimators and Regression estimators. Comparison with simple arithmetic mean estimator. Optimality properties of ratio and regression estimators. Hartly – Ross unbiased ratio type estimator.

Unit-IV. Circular, linear and balanced systematic sampling. Estimation of population mean and its variance. Cluster sampling with equal and unequal clusters. Multi stage and multiphase sampling. Comparison with simple random sampling and Stratified random sampling. Relative efficiency of cluster sampling. Two-stage sampling. Non-sampling errors.

(Practical using R/Python software of the contents of this course)

Text Books

1. Cochran, W.G. (1999) (Reprint 2011). Sampling Techniques. Third edition.Wiley Eastern, New Delhi.
2. Singh, D. and Chaudhury, F.S. (2020). Theory and Analysis of Sample Survey Designs. Second Edition.Wiley Eastern, New Delhi.

References

1. Mukhopadhyay, P. (2009). Theory and Methods of Survey Sampling. Fourth printing (Second Edition). Printice Hall India, New Delhi.

STA08C502: Theory of Estimation (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Explain Sufficiency, Minimal Sufficiency, Unbiasedness& BLUE.

CO2: Describe the ways of obtaining MUVE.

CO3: Describe the properties of consistent estimators.

CO4: Apply different methods of estimation such as method of percentiles, method of moments and method of maximum likelihood, and Bayesian methods.

CO5: Derive SELCI, Bayesian intervals.

CO6: Develop skills in writing programs for handling practical problems arising in sampling studies.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		✓
CO2	✓			✓		✓
CO3	✓			✓		✓
CO4	✓	✓	✓	✓	✓	
CO5	✓		✓	✓		
CO6		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Fisher Information- Sufficient statistic-Minimal sufficient statistic-Exponential family and minimal sufficient statistic.Unbiasedness–best Linear Unbiased estimator–MVUE – Cramer-Rao inequality and its application–Rao-Blackwell theorem-Completeness-Lehman-Scheffe theorem and its application.

Unit-II. Consistent estimator-Examples and properties-CAN estimator-invariance property-asymptotic variance-Multiparameter case-choosing between Consistent estimators.

Unit-III. Method of moments-method of percentiles-method of maximum likelihood- MLE in exponential family-Solution of likelihood equations-Bayesian method of estimation-Prior information-Loss functions (squared error absolute error and zero-one loss functions) – Posterior distribution-estimators under the above loss functions.

Unit-IV. Shortest expected length confidence interval-large sample confidence intervals-unbiased confidence intervals-examples-Bayesian confidence interval.

(Practical using R/Python software of the contents of this course)

Text Books

1. Kale, B.K. andMuralidhran K. (2016). Parametric Inference: An Introduction, Narosa Publishing, New-Delhi.
2. Casella, G. and Berger, R.L. (2002). Statistical Inference. Second Edition. Duxbury, Australia.

References

1. RohatgiV.K. (2003). Statistical Inference. Dover Publications.
2. Rao, C.R. (2002). Linear Statistical Inference and Its Applications- Second Edition. John Wiley &Sons, New York.

STA08C503: Testing of Statistical Hypotheses (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Compute MP and UMP tests corresponding to any given testing problem.

CO2: Formulate LR test, unbiased tests and similar tests corresponding to any given testing problem.

CO3: Apply different non parametric testing methods.

CO4: Construct SPRT corresponding to any given testing problem.

CO5: Solve real life problems in testing using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		✓
CO2	✓			✓		✓
CO3	✓	✓	✓	✓	✓	
CO4	✓		✓	✓	✓	
CO5	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Tests of hypotheses – error probabilities – Most powerful tests – Neyman-Pearson Lemma – Generalized Neyman–Pearson Lemma.

Unit-II. Method of Finding Tests – Likelihood ratio tests – Bayesian tests – Union – intersection and intersection-union tests. Unbiased and invariant tests – Similar tests and locality most powerful tests.

Unit-III. Non-parametric Tests – Single sample tests – the Kolmogorov – Smirnov test– the sign test–the Wilcoxon signed rank test. Two sample tests – the chi-square test for homogeneity – the Kolmogorov – Smirnov test the median test – the Mann-Whitney-Wilcoxon test-Test for independence –Kendall's tau – Spearman's rank correlation coefficient – robustness.

Unit-IV. Sequential Inference – Some fundamental ideas of sequential sampling – sequential unbiased estimation – sequential estimation of mean of a normal population – the sequential probability tests (SPRT) – important properties – the fundamental identity of SPRT.

(Practical using R/Python software of the contents of this course)

Text Books

1. Casella, G. and Berger, R.L, (2002).Statistical Inference -Second Edition. Duxbury, Australia.
2. Rohatgi,V.K. (2003). Statistical Inference. Dover Publications, New York.
3. Rohatgi, V.K. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley & Sons, New York.

References

1. Kale, B.K. andMuralidharan K. (2016). Paremetric Inference: An Introduction, Narosa Publishing, New-Delhi.

STA09C601: Stochastic Processes (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Describe the concepts of discrete time Markov chains, classification of its states and limiting probabilities.

CO2: Describe and use the recurrence relation for generation sizes in a Branching Process and determine the probability of ultimate extinction.

CO3: Explain Poisson processes and its generalizations.

CO4: Explain the renewal processes and Brownian motion processes.

CO5: Derive the birth-death methodology for solving the queueing problems.

CO6: Develop skills in writing programs for solving queueing models.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓		✓		✓
CO2	✓		✓	✓		✓
CO3	✓		✓	✓		✓
CO4	✓		✓	✓	✓	✓
CO5	✓			✓	✓	
CO6		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Concept of Stochastic processes, examples. Specifications. Markov chains-Definitions and examples, Higher transition probabilities- Chapman Kolmogorov equations – classification of states, Stability of a Markov system-limiting behaviour of finite irreducible chains, General ergodic theorem, Gamblers ruin problem. Discrete time Branching processes – Properties of generating functions-mean and variance functions- probability of ultimate extinction.

Unit-II. Poisson process- Definition and derivation of process distribution-interarrival and waiting time distributions, Conditional distribution of arrival times. Generalization of Poisson process:Non –homogenous Poisson process, compound Poisson process, conditional/mixed Poisson process. Continuous time Markov Chains(CTMC) – Birth and death processes, transition probability function of CTMC, Kolmogorov's backward and forward differential equations and limiting probabilities.

Unit-III. Renewal theory- Introduction and preliminaries, Distribution of N(t), Renewal function, Limit theorems and applications, - Elementary Renewal theorem. Renewal reward process-concepts of Regenerative and Semi-Markov processes and inspection paradox.

Unit-IV. Basic characteristics of queues – Markovian models – network of queues. The M/G/I system. The G/M/I model,Erlang's loss system and M|M|k infinite capacity queue. Brownian motion process – hitting time – Maximum variable – variations on Brownian motion – Pricing stock options – Gaussian processes – stationary and weakly stationary processes.

(Practical using R/Python software of the contents of this course)

Text Books

1. Ross, S.M.(2019). Introduction to Probability Models- Twelfth Edition. Academic Press, Elsevier Inc.
2. Medhi, J. (2009). Stochastic Processes- Third Edition. New Age International Publishers.

References

1. Ross, S.M. (1996) (Reprint 2016). Stochastic Processes. Second edition. Wiley.
2. Narahari U Prabhu (2007). Stochastic Processes. Basic theory and applications. World Scientific Publishing. Co. Pvt. Ltd.
3. Karlin, S. and Taylor, H.M. (1975). A First Course in Stochastic Processes- Second Edition. Academic Press, New York.
4. Basu, A.K.(2003). Introduction to Stochastic Processes. Narosa Publishing House, New Delhi.

STA09C602: Design and Analysis of Experiments (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Explain ANOVA, it's regression approach, fixed and random effect models and their analysis.

CO2: Check model adequacy.

CO3: Explore designs like RBD, CRD, LSD, Greaco- LSD, BIBD, Youden square, Lattice design and Factorial designs.

CO4: Explain nested or hierarchical designs and response surface methods

CO5: Discuss ANCOVA.

CO6: Develop skills in writing programs for solving practical problems.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓		✓
CO6		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Application, basic principles, guideline of design of experiments. Statistical techniques. Experiments with single factor. ANOVA. Analysis of fixed effect models – comparison of individual treatment means. Random effect models. Model adequacy checking. Choice of sample size. Regression approach to ANOVA.

Unit-II. Completely Randomized Block design. Randomized block design. Latin square design. Greaco- Latin square design. Incomplete block designs and approaches to analyzing them- BIBD –Recovering of intra block information in BIBD – PBIBD – Youden square – Lattice design.

Unit-III. Factorial designs – definition and principles. Two factor factorial design. Random and mixed models. The general factorial designs- 2^k-factorial experiments – confounding-two level fractional factorial design.

Unit-IV. Nested or hierarchical designs – response surface methods and design – ANCOVA- Missing plot techniques for complete models.

(Practical using R/Python software of the contents of this course)

Text Books

1. Montgomery, D.C. (2013). Design and Analysis of Experiments- Eighth Edition. John Wiley & Sons, New York.

References

1. Das, M. N. and Giri, N. C. (2018). Design and Analysis of Experiments- Third Edition. New Age International (P) Ltd., New Delhi.

STA09C603: Multivariate Analysis (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the properties and applications of multivariate normal distribution.

CO2: Explain partial and multiple correlation coefficients.

CO3: Derive the ML Estimates of the mean vector and the dispersion matrix of multivariate normal.

CO4: Describe the genesis of Wishart distribution with its properties.

CO5: Define HotellingT^2 and Mahalanobis D^2 statistics and able to apply them in testing problems.

CO6: Perform principal component analysis and classification techniques.

CO7: Solve real life problems in testing using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓		✓
CO2	✓			✓		✓
CO3	✓	✓	✓	✓		✓
CO4	✓		✓	✓	✓	✓
CO5	✓	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓
CO7	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Multivariate Normal Distribution – Definition properties, conditional distribution, marginal distribution. Independence of a linear form and quadratic form, independence of two quadratic forms, distribution of quadratic form of a multivariate vector. Partial and multiple correlation coefficients, partial regression coefficients, Partial regression coefficient.

Unit-II. Estimation of mean vector and covariance vector – Maximum likelihood estimation of the mean vector and dispersion matrix. The distribution of sample mean vector inference concerning the mean vector when the dispersion matrix is known for single and two populations. Wishart distribution– properties–generalized variance.

Unit-III. Testing Problems – Mahalnobis D^2 and Hotelling's T^2 Statistics, Likelihood ratio tests – Testing the equality of mean vector, equality of dispersion matrices, testing the independence of sub vectors, sphericity test.

Unit-IV. The problem of classification – classification of one of two multivariate normal population when the parameters are known and unknown. Extension of this to several multivariate normal populations. Population principal components – Summarizing sample variation by principal components components-Iterative procedure to calculate sample principal components

(Practical using R/Python software of the contents of this course)

TextBooks

1. Anderson, T.W. (2004) (Reprint 2017). An Introduction to Multivariate Statistical Analysis. Third edition. John Wiley & Sons, New York.
2. Rao, C.R.(2002). Linear Statistical Inference and Its Applications- Second Edition. John Wiley & Sons, New York.
3. Johnson, R. A. andWichern, D. W. (2002). Applied Multivaraite Statistical Analysis. Pearson Education, India.

References

1. Giri, N.C. (1996). Multivariate Statistical Analysis. Marcel Dekker, New York.
2. Kshirasagar, A.M. (1972). Multivariate Analysis. Marcel Dekker, New York
3. Rencher, A.C. (1998). Multivariate Statistical Analysis. John Wiley & Sons, New York.

STA10C601: Time Series Analysis (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Describe the basics of time series data, its auto-covariance, auto-correlation and stationarity.

CO2: Explain the smoothing methods for determining trend of the data.

CO3: Describe the maximum likelihood, Yule-Walker and least square estimation methods.

CO4: Validate linear models for time series data sets using residual analysis..

CO5: Define ARCH and GARCH models and derive their properties.

CO6: Conduct analysis of spectral density, periodogram and correlogram.

CO7: Develop skills in writing programs for time series analysis.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓	✓	✓
CO2	✓	✓	✓	✓		✓
CO3	✓	✓		✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓			✓		✓
CO6	✓	✓	✓	✓	✓	✓
CO7		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Motivation, Time series as a discrete parameter stochastic process, Auto – Covariance, Auto- Correlation and spectral density and their properties. Exponential smoothing methods- moving average smoothing, single exponential smoothing, Holt method, Holt–Winter smoothing, comparison of methods.

Unit-II. Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR MA periods.

Unit-III. Estimation of ARMA models: Yule – Walker estimation for AR Processes, Maximum likelihood and least squares estimation for ARMA Processes, Residual analysis and diagnostic checking. Forecasting using ARIMA models.

Unit-IV. Spectral analysis of weakly stationary process. Herglotzic Theorem. Periodogram and correlogram analysis. Introduction to no-linear time Series: ARCH and GARCH models(Concepts and basic properties).

(Practical using R/Python software of the contents of this course)

Text Books

1. Box, G.E.P and Jenkins, G.M., Reinsel, G. C. , and Ljung, G. M.(2016). Time Series

Analysis, Forecasting and Control. Fifth Edition. Wiley.
2. Montgomery, D.C., Jennings,C. L. andKulahci,M.(2015). Introduction to Time Series Analysis and Forecasting. Second edition. Wiley Series.
3. Chatfield, C. (2004). The Analysis of Time Series: An Introduction. Sixth Edition. CRC Press.

References

1. Brockwell, P.J. and Davis, R.A. (1991). Time Series: Theory and Methods. Springer, New York
2. Cryer, J. D. and Chan, K. S. (2008). Time series analysis with applications in R. Second edition. Springer.

STA10C602: Regression Methods (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Illustrate the concept of linear regression model.

CO2: Estimate regression parameters and explain the properties of estimators.

CO3: Describe the procedure for testing the significance of regression parameters and construct confidence intervals.

CO4: Build various non-parametric regression models.

CO5: Examine model diagnostics techniques and remedies to overcome violating assumptions.

CO6: Develop skills in solving real life situations in regression analysis using R.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		✓
CO2	✓	✓	✓	✓		
CO3	✓	✓		✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓
CO6		✓	✓	✓		✓

COURSE CONTENTS

Unit-I. Least square estimation-properties of least square estimates-unbiased estimation of σ^2 – distribution theory – maximum likelihood estimation – estimation with linear restrictions- design matrix of less than full rank-generalized least squares.

Unit-II. Hypothesis testing; Likelihood ratio test - F-test – multiple correlation coefficient-Confidence intervals and regions. Simultaneous interval estimation- confidence bands for the regression surface – prediction intervals and band for the response.

Unit-III. The straight line – weighted least squares for the straight line- Polynomials in one variable – piecewise polynomial fitting – Polynomial regression in several variables.

Unit-IV. Bias-incorrect variance matrix-effect of outliers-Diagnosis and remedies: residuals and hat matrix diagonals – non-constant variance and serial Correlations-departures from normality – detecting and dealing with outliers- diagnosing collinearity, Ridge regression and principal component regression.

(Practical using R/Python software of the contents of this course)

Text Books

1. Seber, G. A. F. and Lee, A.J. (2003). Linear Regression Analysis- Second Edition. John Wiley & Sons, New York.
2. Montgomery, D.C., Peck, F.A. and Vining, G. (2001). Introduction to Linear Regression Analysis-Third Edition. John Wiley & Sons, New York.

References

1. Abraham, B. and Ledolter, J. (2005). Introduction to Regression Modeling. Duxbury Press, New York.
2. Sengupta, D. and Jammalamadaka, S.R. (2003). Linear Models: An Integrated Approach. World Scientific Press, New Jersey.

STA10C603: Advanced Probability Theory (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the role of characteristic functions in the study of weak convergence.

CO2: Explain Helly's Convergence theorem, Helly-Bray lemma, Scheffe's theorem and convergence of moments.

CO3: Illustrate the applications of weak law of large numbers.

CO4: Asses the central limit theorems in various situations.

CO5: Describe the smoothing properties of martingales.

CO6: Judge whether a given distribution is infinitely divisible or not.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		✓
CO2	✓			✓		✓
CO3	✓	✓		✓	✓	
CO4	✓		✓	✓		✓
CO5	✓			✓		✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Convergence of distribution functions- weak and complete convergence, Helly convergence theorem, Helly-Bray lemma, Helly-Bray theorem, Statement of Scheffe's theorem, convergence of distribution functions and characteristic functions, Convergence of moments.

Unit-II. Laws of Large Numbers - Convergence of a series of independent random variables-centering and truncation techniques, equivalent sequences, convergence in probability of sequence of partial sums, Kolmogorov inequality, Kolmogorov three series theorem; Weak law of large numbers (both IID and Non-IID cases, (Statement and problems only).). Kolmogorov Strong Law of large numbers (Statement and problems only).

Unit-III. Central Limit Theorem (CLT) – CLT as a generalization of laws of large numbers, Lindeberge-Levy form, Liapounov's form, Lindeberg-Feller form (without proof). Examples and relation between Liapounov's condition.

Unit-IV. Conditioning and Infinite Divisibility: Conditional expectation, properties, Martingales and their properties, Infinite divisibility: Definition, Elementary properties and examples.

Text Books

1. Bhat, B.R. (2024). Modern Probability Theory: An Introductory Text Book. Fifth Edition. New-Age International, New Delhi.

References

1. Ash R. B. and Catherine Doleans-Dade (2000). Probability and Measure Theory. Academic Press, Cambridge.
2. Laha, R.G. and Rohatgi, V.K. (2020). Probability Theory. John Wiley& Sons, New York.
3. Basu, A.K. (2012). Measure Theory and Probability. Second Edition. Printice Hall of India, New Delhi.

STA10C604: Modern Statistical Inference (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Carry out estimation using the likelihood based methods.
CO2: Analyse using Monte Carlo simulation studies
CO3: Estimate bias using Jackniffe method
CO4: Evaluate the standard errors, confidence intervals using the bootstrap methods.
CO5: Develop skills in solving real life problems in statistical inference.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓		✓		✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓		✓
CO4	✓	✓	✓	✓	✓	✓
CO5		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Likelihood based methods: Likelihood construction and estimation, likelihood for regression models, marginal and conditional likelihoods, Information matrix, Methods for maximising the likelihood-Analytical via profile likelihoods, Newton methods, EM algorithm.

Unit-II: Monte Carlo simulation studies-Introduction, Monte Carlo Estimation, Monte Carlo studies and its basic principles, Monte Carlo sample size, Analysing and presenting the results

Unit-III: Jacknife- Basics, Connections to influence curve, Examples, Deleted–d Jacknife, The information reduction approach for variance estimators, Grouped Kacknife, Non-iid situations.

Unit-IV: Bootstrap- Introduction, Bootstrap standard errors, Comparison of variance estimation methods, Bootstrap asymptotics, Bootstrap confidence intervals.

(Practical using R/Python software of the contents of this course)

Text books

1. Boos, D. D. and Stefanski, L. A.(2013). Essential Statistical Inference: Theory and Methods

References

1. Lehmann E. L. and Romano J.P. (2005). Testing Statistical Hypotheses. Third edition. Springer.

STA10C605: Advanced Trends in Statistics (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

CO1: Describe general theory of infinite divisibility and its applications.
CO2: Explain the concept and properties of U-statistics, and their role in non-parametric modelling.
CO3: Perform non-parametric density estimation methods.
CO4: Describe various types of stochastic order relations between random variables in univariate setup.

MAPPING OF Cos to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓	✓	✓
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓		✓	✓	✓	✓

COURSE CONTENTS

Unit I: Infinitely divisible distribution- basic definitions, elementary properties, canonical representation of infinitely divisible characteristic functions, infinitely divisible distributions and convolution semigroups.

Unit II: U-statistics: basic description of U-statistics- variance and other moments of a U-statistic- projection of a U-statistic on the basic observations. Almost sure behaviour of U-statistics- asymptotic distribution theory of U-statistics, non-parametric density estimation.

Unit III: Univariate stochastic orders-usual stochastic order, hazard rate order, likelihood ratio order, convolution order. Mean residual life orders.

Unit IV: Univariate variability orders- convex order, dispersive order, excess wealth order, peakedness order, monotone convex and monotone concave orders, transform orders: convex, star, and super additive orders.

Textbooks

1. Laha, R.G. and Rohatgi, V.K. (2000). Probability Theory. Dover Publications Inc., New York. (For Module (Chapter 4.1)
2. Serfling, R.J.(1980). Approximation Theorems of Mathematical Statistics. John Wiley and Sons, Canada. (For Module II) (Chapter-5)
3. Shaked, M. and Shanthikumar, J. G. (Eds.). (2007). Stochastic Orders. Springer, New York. (For Modules III and IV) (Chapters 1,2, 3 and 4)

STA10P601: Project and Dissertation (12 Credits)

Course Outcomes: On completion of the course, students will be able to

CO1: Discuss the applications of various statistical techniques learned in the entire course in the form of project work.
CO2: Manage real practical situations where statistical analysis are sought.
CO3: Develop professional approach towards writing and presenting an academic report.
CO4: Get more insight about the opportunities in research/career.
CO5: Know the works presented in various journals and current trends in their project/ dissertation area.
CO6: Get an idea of how new developments in the topic have arose and why new computational techniques are needed.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3				✓		✓
CO4			✓	✓		✓
CO5			✓		✓	
CO6	✓		✓	✓		✓

COURSE CONTENTS

As a part of the course work, during the final semester each student may undertake a project work in a selected area of interest under a supervisor in the Department. The topic could be a theoretical work or data analysis type. At the end of the final semester the student shall prepare a report/dissertation which summarizes the project work and submit to the H/D of the parent Department positively before the deadline suggested in the Academic calendar. The project/ dissertation is of 12 credits for which the following evaluation will be followed:

The valuation shall be jointly done by the supervisor of the project in the Department and an internal expert from the approved panel, based on a well-defined scheme of valuation framed by them. If internal experts are not available in the Department, the chairman has the power to nominate an expert from other Departments in the University of any other reputed Institutions as a special case. The following break up is suggested for the valuation.

Criteria for Project Evaluation

1. Review of literature and formulation of the research problem/objective - 20%
2. Methods and description of the techniques used - 15%
3. Analysis and discussion of results - 30%
4. Presentation of the report, organization, linguistic style, reference etc.: - 15%
5. Viva-voce examination based on project/dissertation - 20%.

ELECTIVES

STA07E501: Operations Research (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1. Describe linear programming, simplex method, Big-M method and Two-phase method.
CO2: Explain the concept of duality, related theorems and dual simplex method.
CO3: Discuss transportation problem, assignment problem, sequencing problems and Parametric and sensitivity analysis.
CO4: Explore integer programming problem.
CO5: Describe game theory.
CO6: Develop skills in solving optimization problems using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓		✓		✓
CO2	✓		✓	✓		✓
CO3	✓	✓	✓		✓	
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓		✓	
CO6		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Operations Research.-definition and scope, Linear programming, simplex method, artificial basis techniques, two phase simplex method, Big-M method, duality concepts, duality theorems, dual simplex methods.

Unit-II. Transportation and assignment problems, sensitivity analysis, parametric programming. + Sequencing and Scheduling problems-2 machine n-Job and 3- machine n-Job Problems.

Unit-III. Integer programming: Cutting plane methods, branch and bound technique, application of zero – one programming.

Unit-IV. Game theory: two person zero sum games, minimax theorem, game problem as a linear programming problem. Co-operative and competition games.

(Practical using R/Python software of the contents of this course)

Text Books

1. K.V.Mital and Mohan, C. (1996). Optimization Methods in Operations Research and Systems Analysis- Third Edition. New Age International (Pvt.) Ltd., New Delhi.

References

1. Sinha, S.M. (2006). Mathematical programming theory and methods, Elsevier, a division of Reed Elsevier India Pvt. Ltd., New Delhi.

2. Taha H.A. (2007). Operations Research - An introduction, Eighth edition, Prentice-Hall of India Ltd.

3. KantiSwarup, Gupta, P.K. and Man Mohan (2010).Operations Research, Ninth edition, Sultan Chand & Sons.

4. Paneerselvam, R. (2008).Operations Research, Second edition, Prentice Hall of India Pvt. Ltd., New Delhi.

STA07E502: Official Statistics (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Describe the Indian and International Statistical systems.

CO2: Explain the nature of population growth in developed and developing countries.

CO3: Explain the concept of economic development, growth in per capita income and distributive justice.

CO4: Define the indices of development like Human development index etc.

CO5: Estimate national income through income and expenditure approaches.

CO6: Measure inequality in incomes, and measure poverty through measures of incidence and intensity combined.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		
CO2	✓	✓	✓		✓	✓
CO3	✓	✓	✓	✓		✓
CO4	✓			✓	✓	
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

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. Scope and Contents of population census of India.

Unit-II: Population growth in developed and developing countries, Evaluation of performance of family welfare programmes, projections of labor force and man power. Statistics related to Industries, foreign trade, balance of payment, cost of living, inflation, educational and other social statistics.

Unit-III: Economic development: Growth in per capita income and distributive justice indices of development, human development index. National income estimation- Product approach, income approach and expenditure approach.

Unit-IV: Measuring inequality in incomes: Gini Coefficient, Theil's measure; Poverty measurements: Different issues, measures of incidence and intensity; Combined Measures: Indices due to Kakwani, Senetc.

Text Books

1. Saluja M. R. (2017). Measuring India. Oxford University Press.
2. Basic Statistics Relating to Indian Economy (CSO) 1990
3. Guide to Official Statistics (CSO) 1999
4. Statistical System in India (CSO) 1995

References

1. Principles and Accommodation of National Population Census, UNEDCO.
2. Panse, V.G.: Estimation of Crop Yields (FAO)

STA07E503: Measure and Mathematical analysis (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Illustrate with examples about filed, sigma-field, Borelfields and Borel sigma-field.
CO2: Discuss about measures and its extensions.
CO3: Describe measurable function and its properties.
CO4: Discuss the basic concepts of product space and product measure and associated theorems.
CO5: Evaluate the integrals of functions using Riemann-Stieltjes method.
CO6: Evaluate the derivatives and integrals of functions in the complex plane.
CO7: Determine the singularities and residues of complex functions.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		
CO2	✓		✓	✓		
CO3	✓			✓		✓
CO4	✓			✓	✓	
CO5	✓	✓	✓	✓		✓
CO6	✓	✓	✓	✓		✓
CO7	✓	✓	✓	✓	✓	

COURSE CONTENTS

Unit-I. Field, sigma field, minimal sigma field, monotone class, Borel sets in a real line, Borel sigma field. Definition and fundamental properties of measures- Set function, measurable space, measure, examples of measures, properties of measures. Outer measure. Lebesgue measure, Lebesgue-Steiltjes measure, and outer measure(Concepts only).

Unit-II. Measurable functions – Algebra of measurable functions, Definitions of almost everywhere convergence and convergence in measure, Integration theory and expectation-Definitions and properties, Fatou's lemma, Lebesgue dominated convergence theorem. Product space and product measure definitions, Fubini's theorem statement, Radon-Nikodym theorem statement and its applications.

Unit-III. The Riemann-Stieltjes Integral: Definition and existence of the integral-Refinement of partitions, condition of integrability, properties, definition of integral as limit of sum, Integration and Differentiation.

Unit-IV. Functions of complex variables - Limits. Continuity. Differentiability. Cauchy-Riemann (C-R) equations. Polar form of C-R equations. Analytic functions. Harmonic functions. Partial derivative in relation to $z$and $\bar{z}$. Milne Thomson method for constructiong analytic functions. Complex integration: Contour integral. Cauchy's theorem. Cauchy's integral formula. Cauchy's inequality. Liouville's theorem. Maximum modulus theorem. Taylor series and Laurent series (problems only). Classification of singularities. Residues. Residue theorem (statement and applications only).

Textbooks

1. S. C. Malik and Savita Arora (2022): Mathematical Analysis. Sixth Edition. New Age International Limited.
2. A. K.Basu (2012). Measure Theory and Probability. Second edition.PHI learning Pvt. Limited.
3. Kasana H (2001). Complex variables: Theory and Applications. Prentice Hall of India.

References

1. Robert B. Ash and Catherine A Doleans-Dade (2000). Probabilty and Measure Theory, Second Edition. Academic Press.
2. Royden, H. L. (2021). Real Analysis- Fourth Edition. Prentice Hall of India, New Delhi.

STA07E504: Demographic Techniques (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the sources of demographic Statistics and explain basic demographic measures.
CO2: Construct a life table.
CO3: Explain the measures of fertility.
CO4: Find the point estimates and population projections based on mortality, fertility and migration basis.
CO5: Discuss the ageing of the population.
CO6: Estimate the demographic measures from incomplete data.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓	✓	
CO2	✓	✓	✓	✓		
CO3	✓	✓		✓	✓	✓
CO4	✓	✓		✓	✓	✓
CO5	✓			✓		
CO6	✓	✓		✓	✓	✓

COURSE CONTENTS

Unit-I: Sources of demographic Statistics, Basic demographic measures: Ratios, Proportions and percentages, Population Pyramids, Sex ratio Crude rates, Specific rates, Labour force participation rates, Density of population, Probability of dying.

Unit-II: Life tables: Construction of a life table, Graphs of lx, qx, dx, Functions Lx, Tx and Ex. Abridged life tables Mortality: Rates and Ratios, Infant mortality, Maternal mortality, Expected number of deaths, Direct and Indirect Standardization, Compound analysis, Morbidity.

Unit-III: Fertility: Measures of Fertility, Reproductivity formulae, Rates of natural increase, Fertility Schedules, Differential fertility, Stable populations, Calculation of the age distribution of a stable population, Model Stable Populations.

Unit-IV: Population estimates, Population Projections: Component method, Mortality basis for projections, Fertility basis for projections, Migration basis for projections, Ageing of the population, Estimation of demographic measures from incomplete data.

(Practical using R/Python software of the contents of this course)

Text Books

1. Pollard, A.H. Yusuf, F. and Pollard, G.N (1990). Demographic Techniques, Pergamon Press, Chapters 1-8, 12.

References

1. Keyfitz, N. (1977). Applied Mathematical Demography A Wiley-Interscience Publication
2. Keyfilz, N. (1968). Introduction to the Mathematic of Population Ready, Mass: Addition-Wesley.
3. Keyfilz, N. and Caswell, H. (2005). Applied Mathematical Demography, Third edition, Springer.

STA07E505: Computer Oriented Statistical Methods (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Explain the basic concepts of R software.
CO2: Create vectors and matrices and carry out basic matrix operations using R.
CO3: Visually display, analyze, clarify and interpret numerical data, functions and other Quantitative structures.
CO4: Use various types of looping techniques and conditional statements.
CO5: Carryout different simulation techniques for generating probability distributions.
CO6: Perform various types of probability density estimation techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓		✓	✓
CO4	✓		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Introduction and Basics of R , numeric, arithmetic, assignment, and vectors, Matrices and Arrays, Lists and Data Frames, Special Values, Classes, and Coercion, Basic Plotting in R, Reading and Writing Files.

Unit-II. Functions in R - Calling Functions, Conditions and Loops, Writing Functions, Exceptions, Timings, and Visibility.

Unit-III. Statistics and probability - Elementary Statistics, Basic Data Visualization, Probability, Common Probability Distributions, Methods for generating random variables –Inverse transform method, Acceptance –Rejection Method, Transformation Methods, Sums and Mixtures.

Unit-IV. Probability density estimation -Univariate density estimation – Histograms, frequency polygon density estimate, averaged shifted histogram, Kernel density estimation,

(Practical using R/Python software of the contents of this course)

Text Books

1. Davies, T. M. (2016). The book of R: a first course in programming and statistics. No Starch Press.
2. Rizzo, M. L. (2019). Statistical computing with R. Chapman and Hall/CRC.
3. Michael J. Crawley (2005): "Statistics: An Introduction using R", Wiley, ISBN 0-470-02297-3.

References

1. Phil Spector (2008): “Data Manipulation with R”, Springer, New York, ISBN 978-0-387-74730-9.
2. Maria L. Rizzo (2008): “Statistical computing with R”, Chapman & Hall/CRC, Boca Raton, ISBN 1-584-88545-9.

Elective Course for Other P.G. Programmes under CCSS Scheme

STA07E506: Statistical Techniques for Data Analysis (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Express data graphically.

CO2: Compute different measures of central tendency, dispersion and correlation coefficient.

CO3: Define Probability, conditional probability and independence of events.

CO4: Apply Simple Random Sampling with and without replacement.

CO5: Define Binomial, Poisson and Normal Distributions and apply them for real data modeling.

CO6: Develop confidence intervals under different set up.

CO7: Carry out one way and two way ANOVA.

Unit-I. Biostatistics – Definition, Applying Statistical Methods, Descriptive Methods – Tabular and Graphical Presentation of Data – Frequency Tables, Line Graphs, Bar Charts, Histograms, Stem and Leaf Plots, Dot Plots, Scatter Plots. Measures of Central Tendency – Mean, Median and Mode. Measures of Dispersion – Range and Percentiles, Box Plots, Variance. Correlation Coefficients – Pearson Correlation Coefficient, Spearman Rank Correlation Coefficient.

Unit-II. Probability – Definition, Conditional Probability, Independence of events, Baye's Theorem, Probability Sampling – Sampling With Replacement, Sampling Without Replacement. Designed Experiments – Single and Double Blind experiments. The Life Table – The First Four Columns in the Life Table – Uses of Life Table. Probability Distributions – Binomial , Poisson and Normal, Central Limit Theorem. Sampling Distributions-t ,χ^2 and F distributions (Concepts and applications).

Unit-III. Interval Estimation – Confidence Intervals Based on the Normal Distribution, Confidence Intervals for the Difference of Two Means and Proportions. Tests of Hypotheses – Preliminaries. Testing Hypothesis about the Mean. Testing Hypothesis about the Difference of Two Means. Analysis of Categorical Data – Goodness of Fit Test, Contingency Table.

Unit-IV. Analysis of Variance – Assumptions for the Use of ANOVA – One-Way ANOVA, Two-Way ANOVA. Concept of Regression – Simple Linear Regression, multiple linear regression; Basic concept of multivariate distributions.

(Practical using R/Python software of the contents of this course)

Text Books

1. ParimalMukhopadhyay (2016). Mathematical Statistics. Books and Allied
2. ParimalMukhopadhyay (2012). Theory of Probability.New Central Book Agency.
3. Forthofer, R., Lee, E. S. and Hernandez, M.(2007). Biostatistics – A Guide to Design, Analysis and Discovery- Second Edition. Elsevier.

References

1. Rastogi, V. B. (2015). Fundamentals of Biostatistics-Third Edition. Ane Books India, New Delhi.
2. SundarRao, P. S. S. and Richard, J. (2012). An Introduction to Biostatistics- Third Edition. Prentice Hall of India, New Delhi.
3. S. P. Gupta (2021). Statistical Methods-46th Edition. Sultan Chand & Sons.

STA07E507: Topics in Probability (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Explain the concepts of probability measure, random variables and decomposition of distribution functions.
CO2: Describe induced probability space and notion of vector valued random variables
CO3: Explain Expectation of simple, non-negative and arbitrary random variables
CO4: Distinguish between different types of inequalities such as Cr-inequality, Basic inequality, etc.
CO5: Illustrate convergence of sequence of random variables with examples
CO6: Discuss independence of events, Borel Cantelli Lemma, Borel and Kolmogrov zero- one criteria.
CO7: Describe properties of Characteristic Function, inversion theorem and its applications.

Unit-I. Probability measure, measure, probability space, random variable. Inverse function and properties. Sequence of random variables and limit. Extension of probability measure - Caratheodory extension theorem (without proof). Distribution function. decomposition of distribution function. Vector valued random variables and its distribution function. Induced probability space of a random variable.

Unit-II. Mathematical expectation of simple, non-negative and arbitrary random variables - properties of expectation. Moment generating functions-moments. Inequalities. Cr- inequality, Jenson's inequality, Basic inequality, Markov inequality.

Unit-III. Different modes of convergence. Convergence in probability, convergence in distribution, r^{th} mean convergence, almost sure convergence and their mutual implications.

Unit-IV. Independence of events, classes of events. Independence of random variables. Kolmogorow's 0-1 law, Borel's 0-1 criteria. Borel-Cantelli Lemma. Characteristic Functions- definition, properties, inversion theorem, inversion formula for lattice distributions, Characteristic functions and moments, Taylor's series for characteristic functions, Bochner's theorem (without proof).

Text Books

1. Bhat, B.R. (2019). Modern Probability Theory- Fourth Edition. New-Age International, New Delhi.

References

1. Resnick, S.I. (1999). Probability Paths. Birkhauser, Boston.
2. Laha, R.G. and Rohatgi, V.K. (1979). Probability Theory. John Wiley& Sons, New York.
3. Billingsly, P. (1995). Probability and Measure- Third Edition. John Wiley & Sons, New York.
4. Basu, A.K. (2012). Measure Theory and Probability-Second Edition. Prentice Hall of India, New-Delhi.
5. Rohatgi, V.K. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley&Sons , New York.

STA08E501: Actuarial Statistics (4 Credits)

Course Outcomes: On completion of the course, students should be able to:

CO1: Apply the elements of interest.
CO2: Discuss regular pattern of cash flows and related topics.
CO3: Illustrate and apply individual and collective risk models for a short period.
CO4: Discuss survival distributions and derive survival functions.
CO5: Explain and apply life insurance models.
CO6: Discuss and apply annuity models.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓		✓
CO2	✓			✓		
CO3		✓	✓	✓		✓
CO4	✓	✓		✓		
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Utility theory, insurance and utility theory, models for individual claims and their sums, survival function, curate future lifetime, force or mortality. Life table and its relation with survival function, examples, assumptions, for fractional ages, some analytical laws of mortality, select and ultimate tables, Multiple life functions, joint life and last survivor status, insurance and annuity benefit through multiple life functions evaluation for special mortality laws.

Unit-II. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables central rates of multiple decrement, net single premiums and their numerical evaluations. Distribution of aggregate claims, compound Poisson distribution and its applications.

Unit-III. Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding. Life insurance: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, inferred insurance and varying benefit insurance, recursions, commutation functions. Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportion able annuities-due.

Unit-IV. Net premiums: Continuous and discrete premiums, true monthly payment premiums, apporionable premiums, ums, commutation function accumulation type benefits. Payment premiums, apportionable premiums, commutations functions, accumulation type benefits. Net premium reserves; Continuous and discrete net premium reserve, reserves on a semi continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional

durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

Text Books

1. Atkinson, M.E. and Dickson, D.C.M. (2000). An Introduction to Actuarial Studies. Elgar Publishing.
2. Bedford, T. and Cooke, R. (2001). Probabilistic Risk Analysis- Foundations and Methods. Cambridge University Press, UK.
3. Bowers, N. L., Gerber, H.U., Hickman,J.C., Jones D.A. and Nesbitt,C.J.(1986). Actuarial Mathematics- Second Edition. Society of Actuaries, Ithaca, Illinois, U.S.A.

References

1. Medina, P. K. and Merino, S. (2003). Mathematical Finance and Probability- A Discrete Introduction. Birkhauser, Boston.
2. Neill, A. (1977). Life Contingencies. Heineman, London.
3. Philip, B. et. al (1999). Modern Actuarial Theory and Practice. Chapman & Hall, New York.
4. Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998). Stochastic Process- es for Insurance and Finance. John Wiley & Sons, New York.

STA08E502: Order Statistics (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:
CO1: Compute distribution free confidence intervals for quantiles.
CO2: Show whether order statistics possess Markov property.
CO3: Derive recurrence relations for moments of order statistics.
CO4: Explain Concomitants of Order Statistics.
CO5: Describe the role of order statistics in testing problems.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓		✓		✓
CO2	✓	✓	✓	✓	✓	
CO3	✓	✓		✓		
CO4	✓			✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-1: Basic distribution theory. Order statistics for a discrete parent. Distribution-free confidence intervals for quantiles and distribution-free tolerance intervals. Conditional distributions, Order Statistics as a Markov chain and characterizations. Order statistics for independently distributed variates.

Unit-2: Moments of order statistics. Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics. Recurrence relations & identities. Distribution-free bounds for moments of order statistics and of the range.

Unit-3: Order statistics for dependent variates, Bounds in the case of dependent variates. Random division of an interval. Concomitants. Application to estimation and hypothesis testing, Relation to Poisson Process. Order statistics from a sample containing a single outlier.

Unit-4: Rank order statistics related to the simple random walk. Dwass' technique. Ballot theorem, its generalization, extension and application to fluctuations of sums of random variables. Galton's rank test statistics. Statistics of Kolmogorov-Smirnov type for two samples.

Text Book

1. Arnold, B.C. and Balakrishnan, N. (1989). Relations, Bounds and Approximations for Order Statistics, Vol. 53, Springer, New York.
2. Arnold, B. C., Balakrishnan, N. and Nagaraja H. N. (1992). A First Course in Order Statistics. John Wiley & Sons, New York.
3. David, H. A. and Nagaraja, H. N. (2003). Order Statistics- Third Edition. John Wiley & Sons, New York.

4. Dwass, M. (1967). Simple random walk and rank order statistics. Ann. Math.Statist. 38, 1042-1053.

References

1. Gibbons, J.D. and Chakraborti, S. (1992). Nonparametric Statistical Inference - Third Edition. Marcel Dekker, New York.
2. Takacs, L. (1967). Combinatorial Methods in the Theory of Stochastic Processes, John Wiley & Sons, New York.

STA08E503: Data Mining Techniques (4 Credits)

Course Outcomes: After successful completion of the course, students will be able to:

CO1: Apply classification techniques and concept of decision trees.
CO2: Discuss clustering techniques in statistical and data mining viewpoints.
CO3: Explain and apply unsupervised and unsupervised learning and data reduction techniques.
CO4: Explain and apply artificial neural networks and extensions of regression models.
CO5: Discuss data warehousing and online analytical data processing.
CO6: Explain and apply the techniques of association rules and prediction.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓		✓	✓
CO2	✓		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	
CO5	✓		✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-1: Review of classification methods from multivariate analysis; classification and decision trees. Clustering methods from both statistical and data mining viewpoints; vector quantization.

Unit-II: Unsupervised learning from univariate and multivariate data; Dimension reduction and feature selection. Supervised learning from moderate to high dimensional input spaces.

Unit-III: Artificial neural networks and extensions of regression models, regression trees. Introduction to databases, including simple relational databases.

Unit-IV: Data warehouses and introduction to online analytical data processing. Association rules and prediction; data attributes, applications to electronic commerce.

Text books

1. Berson, A. and Smith, S.J. (1997). Data Warehousing, Data Mining, and OLAP. McGraw- Hill.
2. Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984). Classification and Regression Trees. Wadsworth and Brooks/Cole.
3. Han, J. and Kamber.M. (2000). Data Mining;Concepts and Techniques. Morgan Kaufmann.

References

1. Mitchell, T.M. (1997). Machine Learning. McGraw-Hill.
2. Ripley, B.D. (1996). Pattern Recognition and Neural Networks. Cambridge University Press.

STA08E504: Statistical Quality Control (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Explain the basic ideas and principles of control charts.
CO2: Design various types of control charts for attributes and variables.
CO3: Design Special control charts.
CO4: Explain acceptance sampling by variables, Sampling Plans for single and double specification limits with known and unknown variance
CO5: Draw the OC and ARL for control charts.
CO6: Develop skills in programing and statistical analysis of quality control.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		
CO2	✓	✓				✓
CO3	✓		✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5		✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Management quality- The meaning of the management quality, quality engineering, strategic management quality, management programs for quality. Control chart principles- Causes of variation, statistical aspects of control charting, concept of rational subgrouping, detecting patterns on the control chart.

Unit-II. Control chart for attributes- for pieces nonconforming, for percent nonconforming, for number of nonconformities, OC curves.

Control chart for variables- Range chart, standard deviation chart, mean chart, median chart, midrange chart, OC curves, average run length.

Unit-III. Special control charts- Cumulative sum chart for means, exponentially weighted moving average chart, modified control charts, acceptance control charts.

Unit-IV. Fundamental concepts in acceptance sampling- Advantages and disadvantages, The OC curve. Acceptance sampling for attributes-single sampling plan, double sampling plan, multiple sampling plan and sequential sampling plan. Acceptance sampling by variables- The normality assumption, Types of variable sampling plans, variable sampling plan for a process parameter- to estimate the process average with a single and double specification limits - σ known and unknown, deriving OC functions. Special attribute sampling plans (Concept only) Continuous and skip lot sampling plans, chain sampling plans .

(Practical using R/Python software of the contents of this course)

Text Books

1. Jerry Banks (1989). Principles of Quality Control. Wiley
2. Harrison M. Wadsworth Jr., Kenneth S. Stephans, A. Blanton Godfrey (1986) . Modern Methods for Quality Control and Improvement. Wiley.

References

1. Montgomory, R.C. (1985). Introduction to Statistical Quality Control- Fourth Edition. John Wiley & Sons, New York.
2. Mittage, H.J. and Rinne, H. (1993).Statistical Methods for Quality Assurance. Chapman and Hall, New York.

STA08E505: Analysis of Clinical Trials (4 Credits)

Course Outcomes: On successful completion of this course, student will be able to:

CO1: Describe the basic concepts of clinical trials.
CO2: Develop the design of clinical trials.
CO3: Determine the sample size in clinical trials.
CO4: Conduct bioassays and assimilate the concepts of meta-analysis in clinical trials.
CO5: Develop skills in solving clinical trial analysis using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓		✓	✓	✓
CO2	✓	✓	✓	✓		
CO3	✓	✓	✓	✓		✓
CO4	✓		✓	✓	✓	✓
CO5		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Basics of Clinical Trials: Introduction to clinical trials, the need and ethics of clinical trials, bias and random error in clinical studies, Protocols, conduct of clinical trials, over view of Phase I-IV trials, Data management-data definitions, standard operating procedure, informed consent form, case report forms, database design, data collection systems for good clinical practice.

Unit-II: Design of Clinical Trials: Design of clinical trials- Different phases, Comparative and controlled trials, Random allocation, Randomization, response adaptive methods and restricted randomization. Methods of Blinding, Parallel group designs, Crossover designs, Symmetric designs, Adaptive designs, Group sequential designs, Zelen's designs, design of bioequivalence trials. Outcome measures.

Unit-III: Sample Size Determination and Testing: Sample size determination in one and two sample cases, comparative trials, activity studies, testing and other purposes, unequal sample sizes and case of anova. Surrogate endpoints-selection and design of trials with surrogate endpoints, analysis of surrogate end point data. Reporting and Analysis-Interpretation of result, multi-center trials.

Unit-IV: Meta-Analysis: Meta-analysis in clinical trials-concept and goals, fixed and random effect approaches. Bioassay: Direct and indirect assays, Quantal and quantitative assays, Parallel line and slope ratio assays, Design of bioassays.

(Practical using R/Python software of the contents of this course)

Text Books

1. Friedman, L. M., Furburg, C. D. Demets, L. (1998). Fundamentals of Clinical Trials, Springer Verlag.

2. Jennison and B. W. Turnbull (1999). Group Sequential Methods with Applications to Clinical Trials, CRC Press.
3. Kulinskaya E, Morgeathaler S, Staudte R G (2008). Meta-analysis, Wiley.

References

1. Fleiss, J. L. (1989). The Design and Analysis of Clinical Experiments, Wiley.
2. Marubeni, E. and M. G. Valsecchi (1994). Analyzing Survival Data from Clinical Trials and Observational Studies, Wiley and Sons.
3. Piantadosi S. (1997). Clinical Trials: A Methodological Perspective. Wiley.
4. W Rosenberger, J.M. Lachin (2002). Randomization in Clinical Trials Theory and Practice, Wiley.

STA09E601: **Models and Methods for Lifetime Data (4 Credits)**

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the lifetime/survival probability distributions.
CO2: Analyze complete and censored lifetime data with and without covariates.
CO3: Estimate survival functions using parametric and non-parametric methods.
CO4: Apply and interpret semi-parametric and parametric regression models for survival data.
CO5: Apply statistical techniques to model lifetime data and make predictions.
CO6: Use generalised linear models (GLMs) to analyse data with dependence on one or more explanatory variables.
CO7: Develop skills in the analysis of survival data.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	
CO5		✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓
CO7		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Lifetime distributions-continuous and discrete models-important parametric models: Exponential Weibull, Log-normal, Log-logistic, Gamma, Inverse Gaussian distributions, Log location scale models and mixture models. Censoring and statistical methods.

Unit-II. Kaplan-Meier product-limit estimate and it properties. The Nelson-Aalen estimate, interval estimation of survival probabilities, asymptotic properties of estimators, descriptive and diagnostic plots, estimation of hazard function, methods for truncated and interval censored data, Life tables.

Unit-III. Inference Under exponential model – large sample theory, type-2 censored test plans, comparison of two distributions; inference procedures for Gamma distribution; models with threshold parameters, inference for log-location scale distribution: likelihood based methods: exact methods under type-2 censoring. Weibull regression and accelerated failure time models.

Unit-IV. Proportional hazard models and Cox regression: assumptions and interpretation, Partial likelihood, Rank test for comparing Distributions, Log-rank test, Generalized Wilcoxon test. A brief discussion on multivariate lifetime models and data. Generalized linear models: linear predictor, link function, canonical link, likelihood equation, the iterative reweighted least squares algorithm.

(Practical using R/Python software of the contents of this course)

Text Books

1. Lawless, J.F.(2003). Statistical Methods for Lifetime –Second Edition. John Wiley & Sons, New Jersey.
2. Kalbfiesche, J.D. and Prentice, R.L. (2022). The statistical Analysis of Failure Time Data-Second Edition. John Wiley & Sons, New Jersey.`
3. Miller, R.G.(1981). Survival Analysis. John Wiley & Sons, New York.
4. Dobson, A. J. and A. G. Barnett (2018). An Introduction to Generalized Linear Models, Chapman & Hall.
5. A. McCullagh, P. and Nelder, J. A.(1990). Generalized Linear Models, Chapman & Hall.

STA09E602: Statistical Decision Theory (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Explain different loss functions and decision principle.
CO2: Outline the approach of prior selection.
CO3: Compute Posterior distribution
CO4: Check the admissibility of Bayes rules.
CO5: Solve problems using the general techniques for solving games.
CO6: Develop skills in solving problems in real life using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		
CO2	✓		✓	✓		✓
CO3		✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Statistical decision Problem: Decision rule and loss-randomized decision rule. Decision Principles. sufficient statistic and convexity. Utility and loss, loss functions, standard loss functions, vector valued loss functions.

Unit-II. Prior information: subjective determination of prior density, Non-informative priors, maximum entropy priors, the marginal distribution to determine the prior, the ML-II approach to prior selection, Conjugate priors.

Unit-III. The posterior distribution, Bayesian inference, Bayesian decision theory, empirical Bayes analysis, hierarchical Bayes analysis, Bayesian robustness, Admissibility of Bayes rules.

Unit-IV. Game theory, basic concepts, general techniques for solving games, Games with finite state of nature, the supporting and separating hyper plane theorems. The minimax theorem, statistical games.

(Practical using R/Python software of the contents of this course)

Text Book

1. Berger, O.J. (1985). Statistical Decision Theory and Bayesian Analysis - Second Edition. Springer, New York.

References

1. Ferguson, T.S. (2014). Mathematical Statistics-A Decision Theoretic Approach. Academic Press, New York.

2. Lehman, E.L. (1998). Theory of Point Estimation-Second Edition. John Wiley, New York.

STA09E603: **Machine Learning Models and Applications (4 Credits)**

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Acquire a comprehensive understanding of essential concepts and methods in Statistical Machine Learning.
CO2: Apply machine learning techniques, including linear regression, logistic regression, and support vector machines, to real-world problems
CO3: Analyse the performance of machine learning models, including assessing bias-variance trade-offs, over fitting, and the impact of regularization
CO4: Students will develop and present solutions to real-world problems using a variety of machine learning techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Overview of machine learning and its applications, the distinction between supervised, unsupervised, and semi-supervised learning, simple and multiple linear regression, model fitting, parameter estimation, and hypothesis testing; Model assessment and selection - bias-variance trade-off and over fitting; cross-validation and its application in model selection, performance metrics for classification and regression tasks.

Unit-II: Linear methods for classification: Logistic regression for binary classification; Multiclass classification using one vs rest and one vs one approaches; maximum likelihood estimation and decision boundaries, basis expansion; Regularization and Kernel Methods - Feature transformation and basis expansion techniques; regularization methods (L1, L2) for improving model robustness, kernel methods for nonlinear classification and regression.

Unit-III: Support vector machines - maximum margin classifiers and support vector classification, nonlinear separation using kernel trick, soft - margin classification and handling outliers; Tree - based methods and boosting - decision tree construction and split criteria, ensemble learning with bagging and boosting, introduction to random forests and gradient boosting.

Unit-IV: Unsupervised learning - clustering algorithms (K-means, hierarchical clustering), density estimation with Gaussian mixture models (GMM), recursive feature elimination, principal component analysis (PCA) for dimensionality reduction.

(Practical using R/Python software of the contents of this course)

Text Books

1. Alpaydin, E. (2015). Introduction to Machine Learning, 3rd Edition, Prentice Hall (India).
2. Duda, R. O. Hart, P. E. and Stork, D. G. (2007). Pattern Classification, 2nd Edn., Wiley India.
3. Bishop, C. M. (2006). Pattern Recognition and Machine Learning (Information Science and Statistics), Springer.

References

1. Bhuyan, M. K. (2019). Computer Vision and Image Processing: Fundamentals and Applications, Published by CRC.
2. Haykin, S. O. (2016). Neural Networks and Learning Machines, 3rd Edition, Pearson Education

STA09E604: Econometric Models(4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Explain the meaning and methodology of econometrics.
CO2: Discuss the Leontief input output models and explain the optimization problems in Economics.
CO3: Explain the optimization problems with equality constraints and discuss various production functions like Cobb-Douglas production function and CES production function.
CO4: Discuss the Domar growth model, Solow growth model and Cobweb model.
CO5: Explain the meaning of Multi collinearity, Heteroscedasticity, Autocorrelation and discuss various dynamic econometric models.
CO6: Apply Simultaneous equation models in real life data.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓			✓		
CO2	✓		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓			✓		✓
CO5	✓	✓	✓	✓		✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Basic economic concepts: Demand, revenue, average revenue, marginal revenue, elasticity of demand, cost function, average cost, marginal cost. Equilibrium analysis: Partial market equilibrium-linear and nonlinear model, general market equilibrium, equilibrium in national income analysis. Leontief input output models. Optimization problems in economics, Optimization problems with more than one choice variable: multi product firm, price discrimination.

Unit-II. Optimization problems with equality constraints: utility maximization and consumer demand, homogeneous functions, Cobb-Duglas production function, least cost combination of inputs, elasticity of substitution, CES production function. Dynamic analysis: Domar growth model, Solow growth model, Cobweb model.

Unit-III. Meaning and methodology of econometrics, regression function, multiple regression model, assumptions, OLS and ML estimation, hypothesis testing, confidence interval and prediction. Multicollinearity, Heteroscedasticity, Autocorrelation: their nature, consequences, detection, remedial measures and estimation in the presence of them.

Dynamic econometric models: Auto regressive and distributed lag- models, estimation of distributed lag-models, Koyck approach to distributed lag- models, adaptive expectation model, stock adjustment or partial adjustment model, estimation of auto regressive models, method of instrumental variables, detecting autocorrelation in auto regressive models: Durbin- h test, polynomial distributed lag model.

Unit-IV. Simultaneous equation models: examples, inconsistency of OLS estimators, identification problem, rules for identification, method of indirect least squares, method of two stage least squares .

(Practical using R/Python software of the contents of this course)

Text Books

1. Chiang, A.C. (1984). Fundamental Methods of Mathematical Economics –Third Edition. McGraw – Hill, New York.
2. Gujarati, D.N. (2007). Basic Econometrics -Fourth Edition. McGraw-Hill, New York.

References

1. Johnston, J. (1984). Econometric Methods -Third Edition. McGraw–Hill, New York.
2. Koutsoyiannis, A (1973). Theory of Econometrics, Harper & Row, New York.
3. Maddala ,G.S. (2001). Introduction to Econometrics - Third Edition. John Wiley & Sons, New York
4. Yamane, T. (1968). Mathematics for Economists- An Elementary Survey- Second Edition. Prentice-Hall, India.

STA09E605: Analysis of Longitudinal Data (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the basic concepts of Linear Model in longitudinal data analysis.
CO2: Analyze numerical methods to solve the problems in Linear Model.
CO3: Explain basic concepts of Generalized Linear Model.
CO4: Illustrate and study on missing data mechanism in longitudinal data analysis.
CO5: Describe Multivariate and Time-dependent covariates in longitudinal data analysis.
CO6: Develop skills in analysingreal data using R programming.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		
CO2	✓	✓	✓	✓	✓	✓
CO3	✓			✓		
CO4	✓	✓	✓	✓	✓	✓
CO5	✓		✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: General Linear Model for Longitudinal Data.ML and REML estimation, EM algorithm: General linear mixed-effects model, Inference for ; the random effects, BLUPs, Empirical Bayes , Bayes, Shrinkage Model building and diagnostic, Relaxing parametric assumptions: generalized additive mixed model.

Unit-II. Generalized Linear Model for Longitudinal Data: Marginal models, for binary, ordinal, and count data: Random effects models for binary ordinal and count data: Transition models: Likelihood-based models for categorical data; GEE; Models for mixed discrete and continuous responses.

Unit-III. Dropouts and missing data: Classification missing data mechanism; Intermittent missing Values and dropouts; Weighted estimating equations; Modeling the dropout process (Selection and pattern mixture models).

Unit-IV. Time-dependent covariates and special topics: Dangers of time-dependent covariates: Lagged covariates; Marginal Structural models; Joint models for longitudinal and survival data; Multivariate longitudinal data; Design of randomized and observational longitudinal studies.

(Practical using R/Python software of the contents of this course)

Text Books

1. Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L (2003). Analysis of Longitudinal Data, 2ndEdn. Oxford University press, New York.
2. Fitzmaurice, G.M., Laird, N.M and Ware, J.H.(2004).Applied Longitudinal Analysis, John Wiley & Sons, New York.

References

1. Crowder, M.J. and Hand, D.J. (1990). Analysis of Repeated Measures. Chapman and Hall/CRC Press, London .
2. Davidian,M. and Giltinan, D.M. (1995). Nonlinear Models for Repeated Measurement Data. Chapman and Hall/CRC Press, London.
3. Hand,D and Crowder, M. (1996). Practical Longitudinal Data Analysis. Chapman and Hall/CRC Press, New York. Lindsey, J.K. (1993) Models for Repeated Measurements. Oxford University Press, New York.
4. Little, R.J.A, and Rubin, O.B. (2002).Statistical Analysis with Missing Data, 2nd edition, Wiley, New York.
5. McCullagh,P. and Nelder.J.A (1989). Generalized Linear Models. 2nd edition, Chapman and Hall/CRC Press, London.
6. Weiss, R.E. (2005).Modeling Longitudinal Data. Springer, New York.

STA09E606: Risk Modeling and Survival Analysis (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe the properties of the statistical distributions which are suitable for modeling individual and aggregate losses.

CO2: Analyze and create solutions to problems that are of particular relevance to actuarial work using mathematical and statistical modeling techniques.

CO3: Apply risk modeling theory to a variety of financial and insurance issues.

CO4: Illustrate the use of Compound distributions in risk modeling.

CO5: Develop skills in solving practical problems in risk modeling and survival analysis.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		
CO2	✓	✓	✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓
CO4		✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Loss distributions: Simple loss distributions, The exponential distribution, The gamma distribution, The normal distribution, Other loss distributions-The lognormal distribution, The two-parameter Pareto distribution, The Burr distribution, The three-parameter Pareto distribution, The Weibull distribution, Estimation, The method of moments, Maximum likelihood estimation, The method of percentiles, Goodness-of-fit tests.

Unit-II: Reinsurance: Proportional & Non-proportional reinsurance, Reinsurance arrangements, Excess of loss reinsurance, The reinsurer's conditional claims distribution, Normal and lognormal distributions, Inflation, Estimation, Policy excess.

Unit-III: Risk models 1: General features of a product, Insurable interest, Insurable risk, Models for short-term insurance contracts-The basic model, Discussion of the simplifications in the basic model, Notation and assumptions, The collective risk model, Distribution functions and convolutions, Moments of compound distributions, The compound Poisson distribution, Sums of independent compound Poisson random variables, The compound binomial distribution, The compound negative binomial distribution.

Unit-IV: Risk models 2: Aggregate claim distributions under proportional and individual excess of loss reinsurance, Aggregate excess of loss reinsurance, The individual risk model, Parameter variability / uncertainty, Variability in a heterogeneous portfolio, Variability in a homogeneous portfolio, Variability in claim numbers and claim amounts and parameter uncertainty.

(Practical using R/Python software of the contents of this course)

Text Books

1. Denuit, M., Maréchal, X., Pitrebois, S., & Walhin, J. F. (2007). Actuarial modelling of claim counts: Risk classification, credibility and bonus-malus systems. John Wiley & Sons.
2. Edward W Frees(2010). Regression Modeling with Actuarial and Financial Applications. (International Series on Actuarial Science).
3. Blacker & Yang (1983). Actuaries in Micro insurance: Managing Risk for the Underserved, ACTEX.

References

1. Annette J Dobson (1983). An introduction to statistical modelling. Springer.
2. Hossack,Ian B; Pollard, John H; Zehnwirth, Benjamin (1999). Introductory Statistics with Applications in General Iinsurance- – 2nd ed. – Cambridge University Press.
3. Klugman, Stuart A; Panjer, Harry H; Willmot, Gordon E; Venter, Gary G (1998).Loss Models: from Data to Decisions. .- John Wiley & Sons

STA09E607: Spatial Statistics (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Describe different types of spatial data (geo-statistical, areal, point process)
CO2: Explain how spatial autocorrelation plays a role in statistical modeling
CO3: Model Geo-statistical data from real life situations.
CO4: Analyse aerial unit data from real life situations.
CO5: Model process data from real life situations.
CO6: Apply spacial analytical techniques for real data.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		✓
CO2	✓		✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓
CO4		✓	✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓
CO6	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Introduction – definition, spatial statistics, Geo computation, Geo statistics. Targets of analysis-spatial relationship, spatial pattern and structure, spatial process. Types of spatial analysis-descriptive, explanatory/inferential, predictive. Properties of spatial entities, Quantitative measures of space.

Unit-II: Spatial data and Association – Data and their sources, spatial sampling, Spatial association and pattern, Spatial autocorrelation.

Unit-III: Descriptive and inferential spatial analysis- analysis of point data, fractals and spatial analysis, shape analysis of polygons, analysis of areal data and FRAGSTATS, analysis of directions. Geostatistics and spatial interpolation- introduction, minimum curvature, kriging.

Unit-IV: Spatial modeling- fundamentals of modelling, nature of spatial modelling, model development and accuracy, issues in spatial modelling, spatial modelling in GIS packages, special types of modelling.

(Practical using R/Python software of the contents of this course)

Text Books

1. Gao, J. (2021). Fundamentals of spatial analysis and modelling. CRC Press.
2. Lieshout van, M. N. M. (2019). Theory of Spatial Statistics A Concise Introduction. CRC Press, New York.
3. Gelfand, A.E., Diggle, P., Guttorp, P. and Fuentes, M. (2010). Handbook of Spatial Statistics, CRC Press, New York.

References

1. Peter, J. D. (2014). Statistical Analysis of Spatial and SpatioTemporal Point Patterns. 3rd Edition, CRC Press, New York.
2. Gaetan, C. and Guyon, X. (2010). Spatial Statistics and Modeling, Springer, New York.

STA09E608: Biostatistics (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Discuss types of Biological data and Principles of Bio Statistical design of medical studies.
CO2: Explain the concepts of survival time functions of important parametric models and compare two survival distributions using LR test and Cox's F-test.
CO3: Explain censoring and estimation of parameters using censored data.
CO4: Describe competing risk theory and estimate the probabilities of death by ML method.
CO5: Discuss the basic biological concepts in genetics and clinical trials.
CO6: Develop skills in solving real data analysis in biostatistics using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		
CO2	✓	✓		✓		✓
CO3	✓		✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓		✓	✓		✓
CO6		✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I: Biostatistics-Example on statistical problems in Biomedical Research-Types of Biological data-Principles of Biostatistical design of medical studies- Functions of survival time, survival distributions and their applications viz. exponential, gamma, Weibull, Rayleigh, lognormal, distribution having bath-tub shape hazard function. Parametric methods for comparing two survival distributions(L.R test and Cox's F-test).

Unit-II: Type I, Type II and progressive or random censoring with biological examples, Estimation of mean survival time and variance of the estimator for type I and type II censored data with numerical examples. Non-parametric methods for estimating survival function and variance of the estimator viz. Acturial and Kaplan –Meier methods.

Unit-III: Categorical data analysis (logistic regression) - Competing risk theory, Indices for measurement of probability of death under competing risks and their inter-relations. Estimation of probabilities of death under competing risks by ML method. Stochastic epidemic models: Simple and general epidemic models.

Unit-IV: Basic biological concepts in genetics, Mendel's law, Hardy- Weinberg equilibrium, random mating, natural selection, mutation, genetic drift, detection and estimation of linkage in heredity. Planning and design of clinical trials, Phase I, II, and III trials. Sample size determination in fixed sample designs. Planning of sequential, randomized clinical trials, designs for comparative trials; randomization techniques and associated distribution theory and permutation tests (basic ideas only); ethics behind randomized studies involving human subjects; randomized dose-response studies(concept only).

(Practical using R/Python software of the contents of this course)

Text Books

1. Biswas, S. (1995). Applied Stochastic Processes. A Biostatistical and Population OrientedApproach, Wiley Eastern Ltd.
2. Cox, D.R. and Oakes, D. (1984). Analysis of Survival Data, Chapman and Hall.
3. Elandt, R.C. and Johnson (1975). Probability Models and Statistical Methods in Genetics,John Wiley & Sons.
4. Ewens, W. J. and Grant, G.R. (2001). Statistical methods in Bioinformatics:AnIntroduction, Springer.
5. Friedman, L.M., Furburg, C. andDeMets, D.L. (1998). Fundamentals of Clinical Trials,SpringerVerlag.

References

1. Gross, A. J. and Clark V.A. (1975).Survival Distribution; Reliability Applications inBiomedical Sciences, John Wiley & Sons.
2. Lee, Elisa, T. (1992).Statistical Methods for Survival Data Analysis, John Wiley & Sons.

STA09E609: Statistical Analysis of Categorical Data (4 Credits)

Course Outcomes: On successful completion of the course, students will be able to:

CO1: Discuss type's data and their presentation in contingency tables.

CO2: Explain the Analysis of Multi-way Tables.

CO3: Explain Log-linear models for Two-way contingency Tables.

CO4: Describe different types of association models and their properties.

CO5: Develop skills in the categorical data analysis using programming techniques.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓		✓
CO2	✓		✓	✓	✓	✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓		✓	✓	✓	✓
CO5	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit I: Introduction to Categorical Data - Categorical Data, Discrete Distributions and Related Inference Problems, Statistical Inference with Categorical Data, Classes of Models for Discrete Data. Analysis of Two-way Tables- Analyzing 2 × 2 Tables, Analyzing I × J Tables, Test of Independence for Ordinal Variables, Graphs for Two-way Tables

Unit II: Analysis of Multi-way Tables.-Describing Multi-way Contingency Tables, On Partial and Marginal Tables, Analysis of K 2 × 2 Tables, Types of Independence for Three-way Tables, Graphs for Multi-way Contingency Tables

Unit III: Log-Linear Models- Log-Linear Models for Two-way Tables, On Inference and Fit of Log-Linear Models, Log-Linear Models for Three-way Contingency Tables, Hierarchical Log-Linear Models for Multi-way Tables, Maximum Likelihood Estimation for Log-Linear Models, Model Fit and Selection, Graphical Models, Collapsibility in Multi-way Tables

Unit IV: Association Models - Basic Association Models for Two-way Tables, Maximum Likelihood Estimation for Association Models, Association Model Selection, Features of Association Models, Association Models of Higher Order: The RC(M) Model, Software Applications for Association Models, Association Models for Multi-way Tables..

(Practical using R/Python software of the contents of this course)

Text Books:

1. Kateri M. (2014). Contingency Table Analysis: Methods and Implementation using R, Springer.

References:

1. Agresti, A. (2013). Categorical Data Analysis, III Edition, John Wiley, New York

STA09E610: Advanced Operations Research (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Explain the concept of Non-linear programming;
CO2: Discuss K-T theorems and conditions;
CO3: Explore the concept and problems of Dynamic and Geometric programming;
CO4: Explain inventory management-deterministic and probabilistic models;
CO5: Describe replacement models, and simulation modeling.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓		✓	✓		
CO2	✓		✓	✓		✓
CO3	✓	✓	✓	✓	✓	✓
CO4	✓	✓	✓	✓	✓	✓
CO5	✓		✓	✓	✓	

COURSE CONTENTS

Unit-I. Non-linear programming, Lagrangian function, saddle point, Kuhn-Tucker Theorem, Kuhn Tucker conditions, Quadratic programming, Wolfe's algorithm for solving quadratic programming problem.

Unit-II. Dynamic and Geometric programming: A minimum path problem, single additive constraint, additively separable return; single multiplicative constraint, additively separable return; single additive constraint, multiplicatively separable return, computational economy in DP. Concept and examples of Geometric programming.

Unit-III. Inventory management; Deterministic models, the classical economic order quantity, nonzero lead time, the EOQ with shortages allowed, the production lot-size model. Probabilistic models. the newsboy problem, a lot size. reorder point model.

Unit-IV. Replacement models; capital equipment that deteriorates with time, Items that fail completely, mortality theorem, staffing problems, block and age replacement policies. Simulation modeling: Monte Carlo simulation, sampling from probability distributions. Inverse method, convolution method, acceptance-rejection methods, generation of random numbers, Mechanics of discrete simulation.

(Practical using R/Python software of the contents of this course)

Text Books

1. Mital, K.V. and Mohan, C. (1996). Optimization Methods in Operations Research and Systems Analysis- Third Edition. New Age International (Pvt.) Ltd., New Delhi.
2. Sasieni,M., Yaspan, A. and Friendman, L. (1959). Operations Research- Methods and Problems. John Wiley & Sons, New York.
3. Taha, H.A. (2007). Operations Research – An Introduction. Prentice-Hall Inc., New Jersey.

4. Ravindran, A., Philips, D.T. and Solberg, J.J. (2007). Operations ResearchPrinciples and Practice. John Wiley & Sons, New York.

References

1. Sharma, J.K. (2003). Operations Research- Theory & Applications. Macmillan India Ltd., New Delhi.
2. KantiSwarup, Gupta, P. K., and Manmohan(2010). Operation Research. Sultan Chand & Sons, New Delhi.

STA09E611: Applied Multivariate Methods (4 Credits)

Course Outcomes: On successful completion of the course, students should be able to:

CO1: Analysing Multivariate data using reduction techniques like Principal Component Analysis, Factor analysis and Canonical correlation.

CO2: Formulate multivariate hypothesis tests and drawing appropriate conclusions.

CO3: Discriminate multivariate normal population.

CO4: Identify data reduction techniques.

CO5: Develop skills in solving real life problems in multivariate analysis.

MAPPING OF COs to PSOs

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6
CO1	✓	✓	✓	✓	✓	✓
CO2	✓	✓	✓	✓	✓	✓
CO3	✓		✓	✓	✓	✓
CO4	✓	✓	✓	✓		✓
CO5	✓	✓	✓	✓	✓	✓

COURSE CONTENTS

Unit-I. Principle Component- Factor Analysis-Canonical correlation, Principle component, Maximum likelihood estimates of the principal components and their variance, Extraction of Principal Components and their variances , Factor Analysis – Mathematical model –Estimation of Factor Loading, Canonical correlation – Estimation of canonical correlation and variates, Structural equation models.

Unit-II. Multivariate analysis of variance (MANOVA) – One way and two way classification, Tests independence of sets of variables, Equality of dispersion matrices and Sphericity test.

Unit-III. Discriminant Analysis-Discriminant Analysis, Likelihood ratio method, Bayes and min-max procedure, Discrimination between two multivariate normal population with common dispersion, Sample discriminate function, Estimation – Fisher's method for discriminating among several populations.

Unit-IV. Cluster Analysis - Cluster Analysis, Proximity measures, Hierarchical clustering techniques : single, complete and average linkage algorithms. Non-hierarchical clustering techniques: K means method.Multidimensional Scaling, Correspondence Analysis.

(Practical using R software of the contents of this course)

Text Books

1. Anderson, T.W. (2004) (Reprint 2017). An Introduction to Multivariate Statistical Analysis. Third edition. John Wiley & Sons, New York.
2. Johnson, R A and Wichern D W (2003) : Applied Multivariate Statistical Analysis, Prentice-Hall of India Private Ltd., New Delhi.

References

1. Morrison, F. (2003) : Multivariate Statistical Methods, Brooks/Cole, 4th Revised edn., McGraw Hill Book Company
2. Seber, G. A. F. (2004) : Multivariate Observations, John Wiley.
3. Denis, D. J. (2021) : Applied Univariate, Bivariate and Multivariate Statistics : Understanding Statistics for Social and Natural Scientists, With Application in SPSS and R, John Wiley & Sons.

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Minor Courses in Statistics Offered by

the Department of Statistics, University of Calicut

For the Five Year Integrated PG Programme under CCSS

(Under the Regulations for Choice-based Credit Semester System in the University Teaching Departments with multiple entry and exit options (2024))

Syllabi

(With effect from the academic year 2024-25 onwards)

Course Code	Type	Course Title	Credits	Lecture/ Tutorial/ Practical hours	Total Marks-100	
					CE	ES
I SEMESTER						
STA01C101	Minor	Introductory Statistics	4	4-0-0	50	50
STA01C102	Minor	Statistical Methods	4	4-0-0	50	50
II SEMESTER						
STA02C101	Minor	Probability Models and Statistical Estimation	4	4-0-0	50	50
STA02C102	Minor	Essential Statistics	4	4-0-0	50	50
III SEMESTER						
STA03C201	Minor	Statistical Testing	4	3-0-2	50	50
STA03C202	Minor	Applied Statistical Techniques	4	3-0-2	50	50

STA01C101: Introductory Statistics (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Describe different methods of handling categorical data.
2. Perform various graphical and numerical descriptive procedures for continuous data.
3. Perform correlation and regression analysis for data.
4. Describe basic probability models and related concepts.

Module 1: Descriptive methods for categorical data: Proportions-comparative studies, Screening tests-Specificity and Sensitivity, Displaying proportions- Bar chart, Pie chart, Line graphs. Rates-Measures of morbidity and mortality-crude death rate, incidence rate, follow-up death rate, Standardization of rates. Ratios- Relative risk, Odds and odds ratio, Generalized odds, Mantel–Haenszel Method, Standardized mortality ratio.

Module 2: Descriptive methods for continuous data: Frequency distribution, Histogram and frequency polygon, Cumulative frequency graphs and percentiles, Stem and leaf diagrams, Measures of location, Measures of dispersion, Coefficient of variation, Box plot.

Module 3: Correlation and regression analysis: Correlation, Pearson's correlation coefficient, Spearman's rank correlation coefficient, Kendall's Tau. Simple regression analysis.

Module 4: Probability and Probability models: Concept of probability, Introduction using simple problems, Calculation of odds ratio, Screening tests-Positive and negative predictivity, Measures of agreement-Concordance and discordance, pair-matched case-control study.

Text Books/References

1. Chap T Le (2003), Introductory Biostatistics, Wiley.
2. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi

STA01C102: Statistical Methods (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Explain the fundamental concepts of scales of measurements and types of data.
3. Apply various sampling techniques, while recognizing and minimizing sampling and non-sampling errors.
4. Perform fundamental analyze of qualitative and quantitative bivariate data.
5. Describe fundamental statistical distributions and their properties.
6. Explain basic ideas of statistical inference.

Module 1: Scales of measurements, Types of data: Primary and secondary data, quantitative data, qualitative data, discrete and continuous data, Frequency distribution, grouped and ungrouped data, cumulative frequency distribution, Diagrammatic representation.

Module 2: Census and Sampling. Principle steps in sample survey. Probability sampling. Judgement sampling. Sampling and non-sampling errors. Preparation of a questionnaire. Simple random sampling with and without replacement Stratified sampling. Systematic sampling. Cluster sampling. Sampling methods in study of behaviour.

Module 3: Association of two variables: Summarizing the Distribution of Two Discrete Variables- Contingency Tables for Discrete Data, Joint, Marginal, and Conditional Frequency Distribution, Graphical Representation of Two Nominal or Ordinal Variables. Measures of Association for Two Discrete Variables- Pearson's Chi-square statistics, Cramer's V statistic, Contingency coefficient C, Relative risks and odds ratio. Association between Ordinal and Continuous Variable- Graphical Representation of Two Continuous Variables- correlation coefficient, Spearman's rank correlation coefficient.

Module 4: Probability distributions- Binomial, Poisson, Normal distributions and their properties. Testing of hypothesis- Introduction, Null and alternative hypothesis, level of significance, p-value, one tailed and two-tailed tets, critical region. Sampling distributions.

Text Books/References

1. Singh D. and Chaudhary F. S., Theory and Analysis of Sample Survey Designs – Second edition. New Age International, New Delhi.
2. Cochran, W. G., Sampling Techniques- Third edition . Wiley Eastern, New Delhi.
3. Gupta S.C. and Kapoor V. K., Fundamentals of Applied Statistics. Sultan Chand and Sons.
4. Christian Heumann, Michael Schomaker, Shalabh (2016). Introduction to Statistics and Data Analysis With Exercises, Solutions and Applications in R. Springer.
5. J.K Sharma (2010). Business Statistics Problems and Solutions. Dorling Kindersley (India) Pvt. Ltd.

STA02C101: Probability Models and Statistical Estimation (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Discuss about probability and random variables.
2. State the basic probability laws.
3. Describe standard theoretical discrete and continuous distributions.
4. Define the sampling distributions.
5. Distinguish between point estimation and interval estimation of various population characteristics.
6. Derive maximum likelihood estimators of different discrete and continuous models.

Module 1: Definitions of probability and basic probability laws (without proof), Random variables, Probability mass function, Binomial distribution, Poisson distribution (Probability mass function, mean, variance and their comparisons without proof).

Module 2: Normal distribution and its properties, Calculation of probabilities from normal distribution, Exponential distribution and properties. Definitions and examples of statistic, parameters; Sampling distributions t, F and Chi-square.

Module 3: Estimation of parameters, point and interval estimation, properties of estimation. Estimation of proportions, Proportions of single sample and two samples. Estimation of odds ratio, estimation of correlation coefficients, confidence interval for the mean, variance and ratio of variances of a normal distribution.

Module 4: Maximum likelihood estimation of binomial, Poisson and normal parameters: Illustrations with examples.

Text Books/References

1. Chap T Le (2003), Introductory Biostatistics, Wiley.
2. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi

STA02C102: Essential Statistics (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Describe the components of time series.
2. Describe the various methods for measuring trend and seasonal variations.
3. Demonstrate proficiency in calculating index numbers and conduct tests to ensure the quality of index numbers.
4. Apply statistical quality control techniques to monitor and improve processes.
5. Analyze and interpret tolerance limits, specification limits, and modified control limits to ensure products or processes meet quality standards and specifications.

Module 1: Introduction to time series, Components of time series, Measurement of trend-semi-average method, method of moving average, method of least squares, measurement of seasonal variations-method of simple averages, ratio to trend method.

Module 2: Index numbers: Introduction, The problem of index numbers, Calculation of index numbers: Ratio of simple aggregates, ratio of weighted aggregates, circular test, Tests of good index numbers-Time reversal test, factor reversal test. Cost of living index number.

Module 3: Statistical quality control: Basic concepts, Chance causes, assignable causes, Shewharts Control charts-control chart for variables, $\bar{\bar{x}}$ch art, Range (R) chart, s-chart .

Module 4: Control charts for attributes: p-chart, c-chart, u-chart, Tolerance limits, specification limits and modified control limits, CUSUM charts.

Text Books/References

1. Mukhopadhyay, P. (2016).Applied statistics. Books and Allied (P) Limited.
2. Montgomory, R.C. (1985).Introduction to Statistical Quality Control- Fourth Edition. John Wiley & Sons, New York.

STA03C201: Statistical Testing (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Explain the fundamental concepts basic concepts of hypothesis testing.
2. Interpret p-values and their role in hypothesis testing.
3. Identify suitable tests of significance to test a given hypothesis -large sample test/small sample test for testing different parameters.
4. Apply suitable nonparametric methods for the given data.
5. Develop skills in solving practical problems using R.

Module 1: General concepts of hypothesis testing: Null hypothesis, alternative hypothesis, simple and composite hypothesis, type I error, type II error, critical region, level of significance, power of a test, p-value. (Include illustrative examples).

Module 2: One sample test for mean of a normal population when variance known and unknow, Large sample tests concerning mean, equality of means, proportions, equality of proportions. Small sample tests based on t distribution for mean, equality of means, paired t test, one-way ANOVA.

Module 3: Tests based on chi square distribution: Test for the significance of population variance, goodness of fit and for independence of attributes. Tests based on F distribution, Test for correlation coefficients. (Include real life applications and practical problems).

Module 4: Nonparametric methods: Sign test, Wilcoxan signed-rank test, Wilcoxon rank-sum test, Mann-whitney test, Run test.

(*Practical using R software of the contents of this course)*

Text Books/References

1. Gupta, S. C. and Kapoor, V. K. (2002). Fundamentals of Mathematical Statistics, 11th edition, Sulthan Chand, New Delhi
2. Bernard Rosner (2010). Fundamentals of Biostatistics, seventh edition, Brooks/Cole.
3. Chap T Le (2003), Introductory Biostatistics, Wiley.

STA03C202: Applied Statistical Techniques (4 Credits)

Course Outcomes: After the completion of this course the students will be able to

1. Demonstrate understanding of the principles of experimental design and apply these principles to some standard design of experiments.
2. Analyze and interpret vital statistics and demography data.
3. Calculate and interpret measurements of fertility.
4. Apply regression analysis techniques such as simple logistic regression, polynomial regression, and Poisson regression and interpret their results.
6. Develop skills in solving practical problems using R.

Module 1: Principles of design of experiments – Randomization, Replication and Local control. Completely randomized design. Randomized block design. Latin square design. Balanced incomplete block design.

Module 2: Vital statistics and demography: Measures of mortality-Crude death rate, Specific death rate, infant mortality rate, neonatal mortality rate, fetal death rate, perinatal mortality rate, maternal mortality rate, proportionate cause mortality.

Module 3: Measurements of Fertility: Crude birth rate, general fertility rate, age-specific fertility rate, total fertility rate, measurement of population growth, crude rate of natural increase, GRR, NRR, Stable population.

Module 4: Simple logistic regression, measures of association, polynomial regression, ROC curve and logistic regression, Poisson regression.

(*Practical using R software of the contents of this course)*

References

1. Das M.N. and Giri N.C., Design and Analysis of Experiments. New Age Publications, New Delhi.
2. Chap T Le (2003), Introductory Biostatistics, Wiley.

Sd/-

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