File Ref.No.25539/GA - IV - J2/2013/CU

UNIVERSITY OF CALICUT

Abstract

General and Academic - Faculty of Science - Scheme and Syllabus of MSc Statistics Programme under CCSS PG Regulations 2019 (University Teaching Departments) - Incorporating Outcome Based Education (OBE) with effect from 2020 Admission onwards - Implemented - Subject to ratification of Academic Council - Orders Issued

G & A - IV - J

U.O.No. 5020/2021/Admn Dated, Calicut University.P.O, 29.04.2021

Read:-1. U.O.No. 9010/2019/Admn dated 08.07.2019.
2. Item No. 2 in the minutes of the meeting of the Board of Studies in Statistics (PG) held on 31.03.2021.
3. Remarks of Dean, Faculty of Science dated 21.04.2021.
4. Orders of Vice Chancellor in the file of even No. dated 22.04.2021.

ORDER

1. Vide paper read as (1) above, the Scheme and Syllabus of MSc Statistics Programme in accordance with CCSS PG Regulations 2019 (University Teaching Departments), was implemented in the University with effect from 2019 Admission onwards.
2. Vide paper read as (2) above, the Board of Studies in Statistics (PG) approved the Scheme and Syllabus of MSc Statistics Programme, incorporating Outcome Based Education (OBE) in the existing syllabus, in accordance with CCSS PG Regulations 2019 (University Teaching Departments), with effect from 2020 Admission onwards.
3. The decision of Board of Studies have approved by the Dean, Faculty of Science, vide paper read as (3) above and by the Vice Chancellor, subject to ratification by the Academic Council, vide paper read as (4) above.
4. The Scheme and Syllabus of MSc Statistics Programme, incorporating Outcome Based Education (OBE) in the existing syllabus, in accordance with CCSS PG Regulations 2019 (University Teaching Departments), is therefore implemented, with effect from 2020 Admission onwards, subject to ratification by the Academic Council.
5. Orders are issued accordingly.
6. U.O.No. 9010/2019/Admn dated 08.07.2019 stands modified to this extent. (modified syllabus appended)

Ajitha P.P

Joint Registrar

To

The Head, Department of Statistics, University of Calicut
Copy to: PS to VC/PA to PVC/ PA to Registrar/PA to CE/JCE I/JCE V/DoA/EX and EG Sections/GA I F/CHMK Library/Information Centres/SF/DF/FC

Forwarded / By Order

Section Officer

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

(Under the Calicut University PG Regulations for the Choice-based Credit Semester System (CCSS)-2019 in the University Teaching Departments; Ref: U.O. No.4500/2019/Admn dated 26.03.2019)

Programme Structure & Syllabi
(With effect from the academic year 2020-21 onwards)

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

Course Code	Type	Course Title	Credits
		I SEMESTER (Total Credits: **20**)	
STA1C01	Core	Mathematical Methods for Statistics – I	4
STA1C02	Core	Mathematical Methods for Statistics – II	4
STA1C03	Core	Probability Theory – I	4
STA1C04	Core	Distribution Theory	4
STA1C05	Core	Sampling Theory	4
STA1A01	Audit	Ability Enhancement Course	2(Not in CGPA)
		II SEMESTER (Total Credits: **18**)	
STA2C06	Core	Probability Theory – II	4
STA2C07	Core	Statistical Inference – I	4
STA2C08	Core	Design & Analysis of Experiments	4
STA2C09	Core	Regression Methods	4
STA2C10	Core	Practical – I	2
STA2A02	Audit	Professional Competency Course	2(Not in CGPA)
		III SEMESTER (Total Credits: **20**)	
STA3C11	Core	Statistical Inference – II	4
STA3C12	Core	Multivariate Analysis	4
STA3C13	Core	Stochastic Processes	4
STA3E--	Elective	Elective-I	4
STA3E--	Elective	Elective-II	4
		IV SEMESTER (Total Credits: **18**)	
STA4C14	Core	Project and Dissertation	8
STA4E--	Elective	Elective-III	4
STA4E--	Elective	Elective-IV	4
STA4C15	Core	Practical – II	2

Total Credits: **76** (Core courses-**52**, Project and Dissertation -**8** and Elective courses-**16**).

The courses Elective –I, Elective –II, Elective –III and Elective –IV shall be chosen from the following list.

LIST OF ELECTIVES

Sl. No.	Course Title	Credits
E01	Time Series Analysis	4
E02	Operations Research – I	4
E03	Lifetime Data Analysis	4
E04	Operations Research - II	4
E05	Queueing Theory	4
E06	Statistical Decision Theory	4
E07	Reliability Theory	4
E08	Actuarial Statistics	4
E09	Statistical Quality Assurance	4
E10	Statistics for Biological Sciences (For other P.G. Programmes under CCSS Scheme)	4
E11	Official Statistics	4
E12	Medical Statistics	4
E13	Order Statistics	4
E14	Data Mining Techniques	4
E15	Econometric Models	4
E16	Computer Oriented Statistical Methods	4
E17	Biostatistics	4

Question paper pattern:

For each course there shall be an external examination of duration **3 hours**.. Each question paper will consists of two parts- **Part-A** consisting of **eight paragraph answer type questions**, each of **4 marks**, in which **any four questions** are to be answered; **Part-B** consisting of **four essay type questions** each with two options A and B of **16 marks.** The candidate is required to answer all questions choosing **either Option-A or Option-B** of them. The questions are to be evenly distributed over the entire syllabus within each part.

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MODEL QUESTION PAPER

I/II/III/IV SEMESTER M.Sc. DEGREE (CCSS) EXAMINATION, Month-Year
Branch: Statistics
Course Code: Course Title (__Credits)

Time : **3** Hours Max. Marks: **80**

Section – A

(Answer any **FOUR** questions; each question carries **4** marks)

I (i) ….
(ii) …
(iii) …
(iv) …
(v) …
(vi) …
(vii) …
(viii) … (**4 x 4 = 16**)

Section – B

(Answer either part-**A** or part-**B** of all questions; each question carries **16** marks)

II A. a) ….
b) …….
(-+-)

OR

B. a) …..
b) …. **(-+-)**

III A. a) …
b) …..
(-+-)

OR

B. a) ….
b) ….
(-+-)

IV A. a) ….
b) …..
(-+-)

OR

B. a) …..
b) …..
(-+-)

V A. a) …..
b) ….
(-+-)

OR

B. a) ….
b) …..
(-+-)

Objectives of the Programme

The present programme is intended to provide a platform for talented students to undergo higher studies in the subject as well as to train them to suit for the needs of the society. Apart from teaching 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 softwares such as SPSS, MATLAB and R.

Programme Outcomes:

On successful completion of the programme, students should be able to:

PO-1: Gain sound knowledge in theoretical and practical aspects of Statistics;

PO-2: Acquire the knowledge on modern statistical techniques relevant for today's scientific community;

PO-3: Convince the need for systematic analysis of data in any scientific experiment;

PO-4: Acquire the working knowledge of various statistical softwares and programming languages;

PO-5: Acquire skills and competencies in statistical computing methods and develop algorithms and computer programmes for analyzing complex data sets;

PO-6: Communicate effectively complex statistical ideas to people working in diverse spheres of academics and organizational set ups;

PO-7: Handle and analyze large databases and make meaningful interpretations of the results;

PO-8: Become professionally inclined statistics teachers/statistician/data scientist who have sound knowledge of the subject matter and specialized in knowledge discovery through statistical methods;

PO-09: Acquire basic theoretical and applied principles of statistics with adequate preparation to pursue Doctoral (Ph,D,) degree or enter job force as an applied statistician;

PO-10: Make unique contribution for the development of discipline by addressing complex and challenging problems in emerging areas of the discipline;

PO-11: Continue to acquire relevant knowledge and skills appropriate to professional activities and demonstrate highest standards of ethical issues in Statistical Sciences;

PO-12: Create awareness to become an enlightened citizen with commitment to deliver one's resposibilities within the scope of bestowed rights and privileges.

SYLLABI OF CORE COURSES

STA1C01: Mathematical Methods for Statistics – I(4 Credits)

Course Outcomes:

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

CO1: Explain the concept of Reimann – Stieltjes Integral and evaluate the same under different conditions.

CO2: Discuss the concepts of sequence and series of functions, and determine limits of sequences and test the convergence and series of functions.

CO3: Evaluate the Limit and check the continuity of multivariable functions.

CO4: Compute the derivatives, partial and total derivatives and maxima and minima of multivariable functions.

CO5: Solve systems of linear equations, diagonalize matrices and Classify quadratic forms.

CO6: Compute g inverse of matrices.

CO7: Compute algebraic and geometric multiplicity of characteristic roots.

Unit-I. Reimann – Stieltjes Integral- Definition, existence and properties. Integration by parts. Change of variable - Step functions as integrators. Reduction to finite sum. Monotone increasing integrators. Riemann's condition. Integrators of bounded variations. Mean value theorems. Improper integrals. Gamma and Beta functions.

Unit-II. Sequences and Series of Functions – Point wise convergence and uniform convergence. Tests for uniform convergence. Properties of uniform convergence. Weirstrass theorem.

Unit-III. Multivariable functions. Limit and continuity of multivariable functions. Derivatives, directional derivatives and continuity. Total derivative in terms of partial derivatives, Taylor's theorem. Inverse and implicit functions. Optima of multivariable functions. Determinants.

Unit-IV. Elementary matrices. Determinants. Rank of matrix, inverse. Diagonal reduction. Transformations. Idempotent matrices. Generalized inverse. Solution of liner equations. Special product of matrices. Characteristic roots and vectors. Definition and properties. Algebraic and geometric multiplicity of characteristic roots. Spectral decomposition. Quadratic forms. Classification and reduction of quadratic forms.

Text Books

1. **Apostol, T.M.** (1974). Mathematical Analysis -Second Edition. Narosa Publishing House, New-Delhi. Chapters 7 & 9.
2. **Khuri, A. T.** (1993). Advanced Calculus with Applications in Statistics. John Wiley & Sons, New York. Chapter 7.
3. **Rao, C.R.** (2002). Linear Statistical Inference & Its Applications- Second Edition. John Wiley & Sons, New York.
4. **Graybill, F. A.** (1983). Matrices with Applications in Statistics. John Wiley & Sons, New York.

References

1. **Malik, S.C. & Arora, S.** (2006). Mathematical Analysis- Second Edition. NewAge International, New Delhi.
2. **Lewis, D. W.** (1995). Matrix Theory. Allied Publishers, Bangalore.

STA1C02: Mathematical Methods for Statistics –II (4 Credits)

Course Outcomes:

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

CO1: Recollect basic concepts of set theory and explain the concepts of class of sets& set function.
CO2: Discuss measure and different types of measures such as Outer measure, Lebesgue measure, Lebesgue-Steiltjes measure together with their properties.
CO3: Describe Measurable function and related results.
CO4: Discuss the basic concepts of Product space and product measure
CO5: Explain Multiple integral, Absolute continuity and singularity of measures
CO6: Discuss vector space and linear transformation.

Unit-I. Classes of Sets – Field of sets, sigma field, monotone class and minimal sigma field. Borel sigma field and Borel sets in R and R^p. Set functions. Additivity and sigma additivity – Measures - examples and properties. Outer measure. Lebesgue measure in R and R^p . Lebesgue-Steiltjes measure

Unit-II. Measurable function.Properties.Sequence of measurable functions, convergence, Egoroff's theorem.Integrals of simple, non-negative and arbitrary measurable functions.Convergence of integrals. Monotone convergence theorem, dominated convergence theorem and Fatou's lemma.

Unit-III. Product space and product measure .Multiple integral.Fubini's theorem (without proof).Absolute continuity and singularity of measures.Radon-Nikodym theorem (without proof) and its applications.

Unit-IV.Vector space with real and complex scalars.Subspaces, liner dependence and independence, basis, dimension. Linear transformations and matrices. Jacobean of matrix transformations, functions of matrix argument.

Text Books

1. **Royden, H. L. (1995).** Real Analysis- Third Edition. Prentice Hall of India, New Delhi.
2. **Bartle, R.G. (1996).** The Elements of Integration. John Wiley & Sons, New York.
3. **Lewis, D.W. (1996).** Matrix Theory. Allied Publishers, Bangalore.
4. **Rao,A.R. and Bhimsankaram, P.** (1992). Linear Algebra.Tata McGraw Hill, NewDelhi.
5. **Rao, C.R. (2002).** Linear Statistical Inference and Its Applications-Second Edition. John Wiley & Sons, NewYork.
6. **Mathai, A. M.** (1999). Linear Algebra Part-IIII : Application of Matrices and Determinants, Lecture Notes -Module 3, Centre for Mathematical Sciences, Trivandrum.

References

1. **Kingman, J.F.C. and Taylor, S.J. (1973).** Introduction to Measure and Probability. Cambridge University Press, UK.
2. **Bapat, R.B. (1993).** Linear Algebra and Liner Models. Hindustan Book Agency, New Delhi.

STA1C03: Probability Theory – I(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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 Book

1. **Bhat, B.R. (1999).** Modern Probability Theory- Third 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. (1999).** Measure Theory and Probability. Printice Hall of India, New-Delhi.
5. **Rohatgi, V.K**. (1976). An Introduction to Probability Theory and Mathematical Statistics. John Wiley & Sons , New York.

STA1C04: Distribution Theory(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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, Chisquare and F and their applications.

Unit-I. 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. 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.

Text Books

1. **Rohatgi, V.K. (1976).** An Introduction to Probability Theory and Mathematical Statistics.John Wiley & Sons, New York. Chapter 4- Sections 2, 4 and 5; Chapter 5- Sections 2, 3 and 4; Chapter 7- Sections 3, 4 and 5.
2. **Krishnamoorthy, K. (2006).** Hand book of Statistical Distributions with Applications. Chapman & Hall, New York. Chapters- 8,14,20,23 and 24 Sections- 1,2 and 5.
3. **Johnson, N.L., Kotz. S. and Balakrishnan, N.(2004).** Continuous Univariate Distributions-Vol. I- Second Edition. John Wiley &Sons, New York. Chapter 12 -Sections 4.1, 4.3.

References

1. **Johnson, N.L., Kotz. S. and Balakrishnan,N**. (1995). Continuous Univariate Distributions-Vol. II- Second Edition. John Wiley & Sons, New York.
2. **Johnson, N.L., Kotz. S. and Kemp, A.W. (1992).** Univariate Discrete Distributions. John Wiley & Sons, New York.
3. **Kendall, M. and Stuart, A.** (1977). The Advanced Theory of Statistics- Vol.-I: Distribution Theory- Fourth Edition. Charles Griffin & Co. Ltd., USA.
4. **Goon, A.M. ,Gupta, M.K. and Das Gupta, B. (1991).** Fundamentals of Statistics- Vol. I and Vol. II (2001). World Press, Calcutta.

STA1C05: Sampling Theory(4 credits)

Course Outcomes:

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

CO1: Distinguish between the concepts of probability and non-probability sampling;

CO2: Learn the principles underlying sampling as a means of making inferences about a population and 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 the 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: Employ sampling strategies under varying probability sampling;

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

CO7: Analyse data from multi-stage and multiphase surveys;

CO8: Have an appreciation of the practical issues arising in sampling studies.

Unit-I. Census, Sampling, Probability sampling, 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.

Text Books

1. **Cochran, W.G. (1977).** Sampling Techniques. Wiley Eastern, New Delhi.
2. **Singh, D. and Chaudhury, F.S. (1986).** Theory and Analysis of Sample Survey Designs.Wiley Eastern, New Delhi.

References

1. **Des Raj (1976).** Sampling Theory. McGraw Hill, New York.
2. **Murthy, M. N. (1967).** Sampling Theory and Methods. Statistical Publishing Society, Calcutta.
3. **Mukhopadhyay, P. (1999).** Theory and Methods of Survey Sampling. Printice Hall India, New Delhi.

STA2C06: Probability Theory – II(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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: Distinguish Weak Law of Large Numbers in iid and non-iid set up;

CO4: Illustrate the applications of Weak Laws of large numbers;

CO5: Check whether different types of Central Limit Theorems hold ;

CO6: Define Conditional expectation, martingales and describe the smoothing properties of martingales;

CO7: Define the concept of infinite divisibility, Explain its properties and check whether a given distribution is id or not.

Unit-I. Weak Convergence and Characteristic Functions – Helly's convergence theorem, Helly-Bray lemma, Scheffe's theorem, convergence of distribution functions and characteristic functions, Convergence of moments.

Unit-II. Laws of Large Numbers –Convergence in probability of sequence of partial sums, Kolmogorov inequality and almost sure convergence, almost sure convergence of a series, criterion for almost sure convergence, stability of independent random variables, WLLN(iid and non-iid cases), strong law of large numbers.

Unit-III. Central Limit Thseorem (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, smoothing properties, Infinite divisibility: Definition, Elementary properties and examples.

Text Books

1. **Bhat. B. R. (1999).** Modern Probability Theory- Third Edition. New Age International (P) Limited, Bangalore.
2. **Laha, R.G. and Rohatgi, V.K. (1979).** Probability Theory. John Wiley & Sons, New York.(Chapter-4, Section-1)

References

1. **Rohatgi, V. K. (1976).** An Introduction to Probability Theory and MathematicalStatistics. John Wiley & Sons, New York.
2. **Feller. W. (1993).** An Introduction to Probability Theory and Its Applications. Wiley Eastern, New Delhi.
3. **Rao, C.R. (2002).** Linear Statistical Inference and Its Applications- Second Edition . John Wiley & Sons, New York.
4. **Basu, A.K. (1999).** Measure Theory and Probability. Prentice Hall of India, New Delhi.

STA2C07: Statistical Inference – I(4 Credits)

Course Outcomes:

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

CO1: Explain Sufficiency, Minimal Sufficiency, Unbiasedness & BLUE.
CO2: Describe the ways of obtaining MUVE.
CO3: Check consistency of estimators and how to choose among consistent estimators.
CO4: Apply different methods of estimation such as method of percentiles, method of moments and method of maximum likelihood.
CO5: Describe various loss functions, Risk function and Bayesian estimation under squared error, absolute error and zero-one loss functions
CO6: Derive SELCI. Explain Bayesian and Fudicial intervals

Unit-I. Fisher Information- Sufficient statistic-Minimal sufficient statistic-Exponential family and minimal sufficient statistic. Unbiasedness – best LinearUnbiased 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 and Fiducial intervals.

Text Books

1. **Kale, B.K. (2005).** A First Course on Parametric Inference- Second Edition, Narosa Publishing, New-Delhi.
2. **Casella, G. and Berger, R.L. (2002).** Statistical Inference- Second Edition. Duxbury, Australia.

References

1. **Rohatgi,V. K. (1976).** An Introduction to Probability Theory and Mathematical Statistics. John Wiley & Sons, New York.
2. **Rohatgi,V.K. (1984)**. Statistical Inference. John Wiley & Sons, New York.
3. **Lehman, E.L. (1983).** Theory of Point Estimation. John Wiley & Sons, New York
4. **Rao, C.R. (2002).** Linear Statistical Inference and Its Applications- Second Edition. John Wiley & Sons, New York.

STA2C08: 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.

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 ANOVA

Unit-II. Completely Randomized Block design, randomized block design, Latin square design. Greaco- Latin square design. 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

Text Books

1. **Montgomery, D.C. (2001).** Design and Analysis of Experiments- Fifth Edition. John Wiley & Sons, New York.

References

1. Das, M. N. and Giri, N. C. (2002). Design and Analysis of Experiments- Second Edition. New Age International (P) Ltd., New Delhi.

STA2C09: 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.

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 that 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 – nonconstant variance and serial Correlations-departures from normality – detecting and dealing with outliers- diagnosing collinearity, Ridge regression and principal component regression.

Text Books

1. **Seber, G. A. F. and Lee, A.J. (2003).** Linear Regression Analysis- Second Edition. John Wiley & Sons, New York.
2. **Draper, N.R. and Smith, H. (1988).** Applied Regression Analysis- Third Edition. John Wiley &Sons, New York.

References

1. **Searle, S.R.** (1997). Linear Models. Wiley Paperback Edition. Wiley Inter Science, New Jersey.
2. **Rao, C.R.**(1973). Linear Statistical Inference and Its Applications. Wiley Eastern, New Delhi.
3. **Abraham, B. and Ledolter, J.** (2005). Introduction to Regression Modeling. Duxbury Press, New York.
4. **Sengupta, D. and Jammalamadaka, S.R.** (2003). Linear Models: An Integrated Approach. World Scientific Press, New Jersey.
5. **Montgomery, D.C., Peck, F.A. and Vining, G**. (2001). Introduction to Linear Regression Analysis- Third Edition. John Wiley & Sons, New York.

STA2C10: Practical – I(2 Credits)

Course Outcomes:

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

CO1: Apply the principles of Distribution Theory, Sampling Theory, Estimation, Design & Analysis of Experiments and Regression Methods using real data sets.

CO2: Know the formulas to be applied for the analysis.

CO3: Write the R codes for the analysis of the given data.

CO4: To install and load the packages required to run the R codes.

CO5: Enter the data given for analysis

CO6: Explain how to make conclusions and write the inference for the data analysis based on the output obtained.

The practical is based on the following core papers in the first and the second semesters:

1. STA1C04:Distribution Theory
2. STA1C05:Sampling Theory
3. STA2C07: Statistical Inference –I
4. STA2C08:Design and Analysis of Experiments
5. STA2C09:Regression Methods

Practical are to be done using scientific programmable calculators or personal computers. The question paper for the external examination will be set by the external examiner in consultation with the chairman. The practical will be valued on the same day the examination is held out and the marks will be finalized on the same day.

STA3C11: Statistical Inference-II(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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.

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

Text Books

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

References

1. **Fraser, D.A. (1957).** Non – parametric Methods in Statistics. John Wiley & Sons, New York.
2. **Lehman, E.L. (1986).** Testing of Statistical Hypotheses. John Wiley & Sons, New York.
3. **Forguson, T.S**. (1967). Mathematical Statistics: A Decision – Theoretic Approach. Academic Press, New York.

STA3C12: Multivariate Analysis(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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 Hotelling T^2 and Mahalanobis D^2 statistics and able to apply them in testing problems.
CO6: Classify multivariate normal populations.
CO7: Be familiar with principal components and their analysis.

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 man 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 – Iterative procedure to calculate sample principal components.

Text Books

1. **Anderson, T.W. (1984).** Multivariate Analysis. John Wiley & Sons, New York.
2. **Rao, C.R.(2002).** Linear Statistical Inference and Its Applications- Second Edition. John Wiley & Sons, New York.

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**.**

STA3C13: Stochastic Processes(4 Credits)

Course Outcomes:

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

CO1: Explain the concepts of stochastic processes;
CO2: Classify stochastic processes
CO3: Distinguish between strict stationarity and wide-sense stationary .
CO4: Describe the concepts of Discrete time Markov chains, classification of its states and limiting probabilities;
CO5: Describe and use the recurrence relation for generation sizes in a Branching Process and determine the probability of ultimate extinction;
CO6: Explain continuous time Markov chains, Poisson processes and its generalizations;
CO7: Employ birth-death methodology for solving queueing problems;
CO8: Explain the renewal processes and Brownian motion processes.

Unit-I. Concept of Stochastic processes, examples. Specifications. Markov chains- Chapman Kolmogorov equations – classification of states – limiting probabilities Gamblers ruin problem – mean time spent in transient states – branching processes Hidden Markov chains.

Unit-II. Exponential distribution – counting process – inter arrival time and waiting time distributions. Properties of Poisson processes – Conditional distribution of arrival times. Generalization of Poisson processes – non –homogenous Poisson process, compound Poisson process, conditional mixed Poisson process. Continuous time Markov Chains – Birth and death processes – transition probability function-limiting probabilities.

Unit-III. Renewal processes-limit theorems and their applications. Renewal reward process. Regenerative processes, semi-Markov process. The inspection paradox Insurers ruin problem.

Unit-IV. Basic characteristics of queues – Markovian models – network of queues. The M/G/I system. The G/M/I model, Multi server queues. Brownian motion Process – hitting time – Maximum variable – variations on Brownian motion – Pricing stock options – Gaussian processes – stationary and weakly stationary processes.

Text Books

1. **Ross, S.M.(2007).** Introduction to Probability Models- Nineth Edition. Academic Press, New York.

References

1. **Medhi,J. (1996).** Stochastic Processes- Second Edition. Wiley Eastern, New Delhi**.**
2. **Karlin, S. and Taylor, H.M.** (1975). A First Course in Stochastic Processes- Second Edition. AcademicPress, New York.
3. **Cinlar, E.** (1975). Introduction to Stochastic Processes. Prentice Hall, New Jersey.
4. **Basu, A.K**.(2003). Introduction to Stochastic Processes. Narosa Publishing House, New Delhi.

STA4C14: Project and Dissertation(8 Credits)

Course Outcomes:

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

CO1: Discuss the applications of various statistical techniques learned in the entire course in the form of project work.

CO2: Manage a real practical situation where a statistical analysis is 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.

As a part of the course work, during the fourth semester each student has to 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 fourth 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 8 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 External Expert appointed by the University, based on a well defined scheme of valuation framed by them. The following break up of weightage is suggested for its valuation.

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

STA4C15: Practical – II(2 Credits)

Course Outcomes:

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

CO1: Apply the principles of Testing of Hypotheses, Multivariate Analysis and the two electives offered in Semester IV using real data sets.

CO2: Know the formulas to be applied for the analysis.

CO3: Write the R codes for the analysis of the given data.

CO4: To install and load the packages required to run the R codes.

CO5: Enter the data given for analysis

CO6: Explain how to make conclusions and write the inference for the data analysis based on the output obtained.

The practical is based on the following courses in the third and fourth semesters**.**

1. STA3C11: Statistical Inference – II
2. STA3C12: Multivariate Analysis
3. Elective – III
4. Elective – IV

Practical is to be done using scientific programmable calculators or personal computer. The question paper for the external examination will be set by the external examiner in consultation with the chairman.. The practical will be valued on the same day the examination is carried out and the mark sheet will be given to the chairman on the same day.

LIST OF ELECTIVES

Course Code	Course Title	Credits
STA-E01	Time Series Analysis	4
STA-E02	Operations Research – I	4
STA-E03	Lifetime Data Analysis	4
STA-E04	Operations Research – II	4
STA-E05	Queueing Theory	4
STA-E06	Statistical Decision Theory	4
STA-E07	Reliability Theory	4
STA-E08	Actuarial Statistics	4
STA-E09	Statistical Quality Assurance	4
STA-E10	Statistics for Biological Sciences (For other P.G. Programmes under CCSS Scheme)	4
STA-E11	Official Statistics	4
STA-E12	Medical Statistics	4
STA-E13	Order Statistics	4
STA-E14	Data Mining Techniques	4
STA- E15	Econometric Models	4
STA-E16	Computer Oriented Statistical Methods	4
STA-E17	Biostatistics	4

STA-E01: TIME SERIES ANALYSIS(4 Credits)

Course Outcomes:

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

CO1: Define time series in time and frequency domain;
CO2: Describe various types of smoothing techniques;
CO3: Assess the stationarity of time series;
CO4: Identify suitable ARMA models for the stationary component of the given time series;
CO5: Estimate the parameters of the identified models;
CO6: Discuss the validity of the model by residual analysis;
CO7:Carry out Prediction by MMSE methods;
CO8:Analyze Spectral density and periodogram;
CO9: Identify a model for the given time series;
CO10: Describe ARCH and GARCH models.

Unit-I. Motivation, Time series as a discrete parameter stochastic process, Auto – Covariance, Auto- Correlation and spectral density and their properties. Exploratory time series analysis, Test for trend and seasonality, Exponential and moving average smoothing, Holt – Winter smoothing, forecasting based o n smoothing, Adaptive smoothing.

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, Discussion (without proof) of estimation of mean, Auto-covariance and auto-correlation function under large samples theory, Residual analysis and diagnostic checking. Forecasting using ARIMA models, Use of computer packages like SPSS.

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

Text Books

1. **Box G.E.P and Jenkins G.M.** (1970)**.** Time Series Analysis, Forecasting and Control. Holden-Day, SanFransisco.
2. **Brockwell P.J.and Davis R.A.** (1987). Time Series: Theory and Methods. Springer, New York.
3. **Abraham B and Ledolter J.C.** (1983). Statistical Methods for Forecasting, John Wiely & Sons, New York.

References

1. **Anderson T.W** (1971). Statistical Analysis of Time Series. John Wiley & Sons, New York.
2. **Fuller W.A.** (1978). Introduction to Statistical Time Series. John Wiley & Sons, New York.
3. **Kendall M.G.** (1978)**,** Time Series. Charles Graffin, London.
4. **K.Tanaka** (1996)**.** Time Series Analysis. John Wiely & Sons, New York.

STA-E02: Operations Research – I (4Credits)

Course Outcomes:

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

CO1: Describe linear programming;
CO2: Discuss simplex method, Big-M method and Two-phase method;
C03: Explain the concept of duality, related theorems and dual simplex method;
CO4: Discuss transportation problem, assignment problem and sequencing problems and parametric and sensitivity analysis;
CO5: Explore integer programming problem;
CO6: Describe game theory.

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.

Text Book

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. **Hadley, G. (1964).** Linear Programming. Oxford & IBH Publishing Co, New Delhi.
2. **Taha. H.A. (1982)**. Operations Research- An Introduction. Macmillan, New York.
3. **Hiller FS. And Lieberman, G.J. (1995).** Introduction to Operations Research. McGraw Hill, New York.
4. **Kanti Swarup, Gupta, P.K and John, M.M**.(1985): Operations Research. Sultan Chand & Sons, New Delhi.

STA-E03: Lifetime Data Analysis(4 Credits)

Course Outcomes:

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

CO1:Explain the basic concepts and ideas of lifetime/survival analysis;
CO2: Examine the structural properties and methods for standard lifetime probability distributions;
CO3: Analyze complete and censored lifetime data with and without covariates;
CO4: Estimate survival functions using parametric and non-parametric methods;
CO5: Apply and interpret semi-parametric and parametric regression models for survival data;
CO6: Apply statistical techniques to model lifetime data and make predictions;
CO7: Use some key methods in system reliability modeling as well as survival analysis.

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. The 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 application to Weibull andextreme value distributions, comparison of distributions.

Unit-IV. Log-location scale (Accelerated Failure time) model, Proportional hazard models, Methods for continuous multiplicative hazard models, Semi-parametric maximum likelihood-estimation of continuous observations, Incomplete data; Rank test for comparing Distributions, Log-rank test, Generalized Wilcoxon test. A brief discussion on multivariate lifetime models and data.

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. (1980).** The statistical Analysis of Failure Time Data. John Wiley & Sons, New Jersey.

References

1. **Miller, R.G.(1981).** Survival Analysis. John Wiley & Sons, New York.
2. **Bain, L.G.(1978).** Statistical Analysis of Reliability and Life testing Models. Marcel Decker, New York.
3. **Nelson, W. (1982).** Applied Life Data Analysis.
4. **Cox, D.R and Oakes, D.(1984).** Analysis of Survival Data. Chapman & Hall, New York.
5. **Lee, E. T. (1992).** Statistical Methods for Survival Data Analysis. John Wiley& Sons, New York.

STA-E04: Operations Research – II (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;
CO6: Describe Simulation modeling.

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.

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. (1997).** Operations Research – An Introduction. Prentice-Hall Inc., New Jersey.
4. **Ravindran, A., Philips, D.T. and Solberg, J.J. (1987).** Operations Research-Principles and Practice. John Wiley & Sons, New York.

References

1. **Sharma, J.K. (2003).** Operations Research- Theory & Applications. Macmillan India Ltd., New Delhi.
2. **Manmohan, Kanti swarup and Gupta(1999).** Operation Research. Sultan Chand & Sons, New Delhi.

STA-E05: Queueing Theory (4 Credits)

Course Outcomes:

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

CO1: Have rigorous understanding of the theoretical background of queueing systems;

CO2: Compute quantitative metrics of performance for queueing systems;

CO3: Apply and extend queueing models to analyze real world systems.

CO4: Describe various Markovian queueing models and their analysis

CO5: Explain transient behaviour of queueing models and analysis of advanced Markovian models with bulk arrival and bulk service

CO6: Describe various queueing networks and their extensions

CO7: Explain various non Markovian queueing models and their analysis

Unit-I. Introduction to queueing theory, Characteristics of queueing processes, Measures of effectiveness, Markovian queueing models, steady state solutions of the M/M/I model, waiting time distributions, Little's formula, queues with unlimited service, finite source queues.

Unit-II. Transient behavior of M/M/1 queues, transient behavior of M/M/∞. Busy period analysis for M/M/1 and M/M/c models. Advanced Markovian models. Bulk input $M^{[X]}$ /M/1 model, Bulk service $M/M^{[Y]}$ /1 model, Erlangian models, $M/E_k/1$and $E_k/M/1$. A brief discussion of priority queues.

Unit-III. Queueing networks-series queues, open Jackson networks, closed Jackson network, Cyclic queues, Extension of Jackson networks. Non Jackson networks.

Unit-IV. Models with general arrival pattern, The M/G/1 queueing model, The Pollaczek-khintchine formula, Departure point steady state systems size probabilities, ergodic theory, Special cases M/Ek/1 and M/D/1, waiting times, busy period analysis, general input and exponential service models, arrival point steady state system size probabilities.

References

1. **Gross, D. and Harris, C.M.(1985).** Fundamentals of Queueing Theory- Second Edition. John Wiley & Sons, New York.
2. **Kleinrock, L. (1976).** Queueing Systems, Vol. I & Vol.II. John Wiley & Sons, NewYork.
3. **Ross, S.M. (2007).** Introduction to Probability Models- Nineth Edition. Academic Press, New York.
4. **Bose, S.K. (2002).** An Introduction to Queueing Systems. Kluwer Academic/ Plenum Publishers, New York.

STA-E06: Statistical Decision Theory(4 Credits)

Course Outcomes:

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

CO1: Explain different loss functions and decision principle.

CO2: Describe the use of prior information in decision making.

CO3: Compute Posterior distribution and check the admissibility of Bayes rules.

CO4: Know general techniques for solving games.

Unit-I. Statistical decision Problem – Decision rule and loss-randomized decision rule. Decision Principle – 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 he 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.

Text Book

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

References

1. **Ferguson, T.S. (1967).** Mathematical Statistics-A Decision Theoretic Approach. Academic Press, New York.
2. **Lehman, E.L.(1983).** Theory of Point Estimation. John Wiley, New York.

STA-E07: Reliability Theory(4 Credits)

Course Outcomes:

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

CO1: Explain the reliability concepts and measures;

CO2: Discover the system reliability using the concept of structure functions;

CO3: Explain various lifetime probability distributions and their structural properties;

CO4: Describe various concepts and different notions of ageing used in reliability analysis and their inter relations;

CO5: Estimate the reliability function for complete and censored samples;

CO6: Describe univariate and bivariate shock models and carry out reliability estimation based on failure times;

CO7: Describe Maintenance and Replacement Policies.

Unit-I. Reliability concepts and measures; components and systems; coherent systems; reliability of coherent systems; cuts and paths; modular decomposition; bounds on system reliability; structural and reliability importance of components.

Unit-II. Life distributions; reliability function; hazard rate; common life distributions-exponential, Weibull, Gamma etc. Estimation of parameters and tests in these models. Notions of ageing; IFR, IFRA, NBU, DMRL, and NBUE Classes and their duals; closures or these classes under formation of coherent systems, convolutions and mixtures.

Unit-III. Univariate shock models and life distributions arising out of them; bivariate shock models; common bivariate exponential distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.

Unit-IV. Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process. Reliability growth models; probability plotting techniques; Hollander-Proschan and Deshpande tests for exponentiality; tests for HPP vs. NHPP with repairable systems. Basic ideas of accelerated life testing.

References

1. **Barlow, R.E. and Proschan, F.(1985).** Statistical Theory of Reliability and Life Testing. Holt, Rinehart and Winston, New York.
2. **Bain L.J. and Engelhardt** (1991). Statistical Analysis of Reliability and Life Testing Models. Marcel Dekker, New York.
3. **Aven, T**. and **Jensen, U.** (1999). Stochastic Models in Reliability. Springer, NewYork.
4. **Lawless, J.F.** (2003). Statistical Models and Methods for Lifetime -Second Edition. John Wiley & Sons, New York.
5. **Nelson, W** (1982). Applied Life Data analysis. John Wiley & Sons, New York.
6. **Zacks, S.** (1992). Introduction to Reliability Analysis- Probability Models and Statistics Methods. Springer, New York.

STA-E08: 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.

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 apportionable 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.

References

1. **Atkinson, M.E. and Dickson, D.C.M. (2000).** An Introduction toActuarial 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.
4. **Medina, P. K. and Merino, S. (2003).** Mathematical Finance and Probability- A Discrete Introduction. Birkhauser, Boston.
5. **Neill, A. (1977).** Life Contingencies. Heineman, London.
6. **Philip, B. et. al (1999).** Modern Actuarial Theory and Practice. Chapman & Hall, New York.
7. **Rolski, T., Schmidli, H., Schmidt, V. and Teugels, J. (1998).** Stochastic Processes for Insurance and Finance. John Wiley & Sons, New York.
8. **Spurgeon, E.T. (1972).** Life Contingencies, Cambridge UniversityPress.
9. Relevant Publications of the Actuarial Education Co., 31, Bath Street,Abingdon, Oxford shire OX143FF (U.K.)

STA-E09: Statistical Quality Assurance(4 Credits)

Course Outcomes:

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

CO1: Apply different statistical quality control techniques including various types sampling plans for attributes and measure the performance of these plans;

CO2: Explain and design various types of control charts, design control charts and distinguish between them;

CO3: Explain acceptance sampling by variables, Sampling Plans for a single and double specification limits with known and unknown variance, Sampling plans with double specification limits;

CO4: Compare sampling plans by variables and attributes and Continuous sampling plans I, II & III.

Unit-I. Quality and Quality assurance, Methods of Quality assurance, Introduction to TQM. Acceptance sampling for attributes, Single sampling, Double sampling. Multiple sampling and Sequential sampling plans. Measuring the performance of these sampling plans

Unit-II. Acceptance sampling by variables, sampling plans for single specification limit with known and unknown and unknown variance, Sampling plans with double specification limits., comparison of sampling plans by variables and attributes, Continuous sampling plans I , II,III

Unit-III. Control charts, Basic ideas, Designing of control charts for tshe number of non-conformities. Mean charts. Median charts. Extreme value charts, R-charts, and S-charts ARI, Economic design of control charts.

Unit-IV. Process capability studies, Control charts with memory – CUSUM charts, EWMA mean charts, OC and ARI for control charts, Statistical process control, Modeling and quality programming. Orthogonal arrays and robust quality.

Text Books

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. Chapters-13 and 14.
3. **Oakland, J.S. and Follorwel, R.F. (1990).** Statistical Process Control. East-West Press, New York. Chapters- 13 and 14.
4. **Schilling, E.G. (1982).**Acceptance Sampling in Quality Control. Marcel Dekker, New York.

References

1. **Duncan, A.J. (1886).** Quality Control and Industrial Statistics.
2. **Gerant, E.L. and Leaven Worth, R.S. (1980).** Statistical Quality Control. Mc Graw Hill, New York.
3. **Chin-Knei Chao (1987).** Quality Programming, John Wiley & Sons, New York.

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

STA-E10: Statistics for Biological Sciences(4 Credits)

Course Outcomes:

On successful completion of the course, students should 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 Probabilities, Independent Events, Baye's Theorem, Probability in 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, The Central Limit Theorem.

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 – The Goodness of Fit Test, The 22 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.

Text Book

1. **Forthofer, R. N., Lee, E. S. and Hernandez, M.**(2007). Biostatistics – A Guide to Design, Analysis and Discovery- Second Edition. Elsevier, New Delhi.

References

1. **Rastogi, V. B.** (2006). Fundamentals of Biostatistics. Ane Books India, New Delhi.
2. **Sundar Rao, P. S. S. and Richard, J.** (1996). An Introduction to Biostatistics- Third Edition. Prentice Hall of India, New Delhi.

STA-E11: 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.

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, Sen etc.

Suggested Readings:

1. Basic Statistics Relating to Indian Economy (CSO) 1990
2. Guide to Official Statistics (CSO) 1999
3. Statistical System in India (CSO) 1995
4. Principles and Accommodation of National Population Census, UNEDCO.
5. **Panse, V.G**.: Estimation of Crop Yields (FAO)
6. Family Welfare Year Book. Annual Publication of D/O Family Welfare.
7. Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
8. CSO (1989)a: National Accounts Statistics- Sources and Methods.
9. **Keyfitz, N (1977).** Applied Mathematical Demography. Springer, New York.
10. **Sen, A (1977):** Poverty and Inequality.
11. UNESCO: Principles for Vital Statistics Systems, Series M-12.
12. CSO (1989)b: Statistical System in India
13. **Chubey, P.K (1995).** Poverty Measuremen. , New Age International, New Delhi.

STA-E12: Medical Statistics (4 Credits)

Course Outcomes:

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

CO1: Apply and analyze proper design strategy for epidemiology studies;
CO2: Determine proper sample size for the study and understand various efficient design models;
CO3: Build and Analyze the models for censored data, Longitudinal data and multivariate data;
CO4: Understand communicating results of epidemiology and the ethical issues in it.

Unit-1: Study designs in epidemiology. Measures of disease occurrence and association, variation and bias. Identifying non-causal association and confounding. Defining and assessing heterogeneity of effects, interaction.

Unit-2: Sensitivity and specificity of diagnostic test, Cohort Study designs, statistical power and sample size computations. Log-linear models, 2xK and 2x2x2 contingency tables. Logistic model. Analysis of binary data

Unit-3: Cross-control study designs, matched case-control studies, Survival data, Censoring, Proportional hazards model, multivariate survival data.

Unit-4: Causal Inference, Longitudinal data, Communicating results of epidemiological studies, ethical issues in epidemiology.

References:

1. **Selvin** : Statistical analysis of epidemiological data.
2. **Diggle, Liang and Zeger** : Analysis of longitudinal data
3. **Piantadosi** : Clinical trials
4. **Agresti** : Categorical Data Analysis.
5. **Clayton and Hills** : Statistical methods in Epidemiology
6. **McCullagh and Nelder** : Generalized Linear Models.
7. **Brookemeyer and Gail** : AIDS Epidemiology : A Quantitative Approach
8. **Zhou, Obuchowski and McClish** : Statistical Methods in Diagnostic Medicine

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STA–E13: 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.

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. Distibution-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.

References:

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.

5. **Gibbons, J.D. and Chakraborti, S. (1992).** Nonparametric Statistical Inference - Third Edition. Marcel Dekker, New York.

6. **Takacs, L. (1967).** Combinatorial Methods in the Theory of Stochastic Processes, John Wiley & Sons, New York.

STA–E14 : Data Mining Techniques (4 Credits)

Course Outcomes:

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

On completion of the course, students should 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.

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

Unit-2: Unsupervised learning from univariate and multivariate data; Dimension reduction and feature selection. Supervised learning from moderate to high dimensional input spaces;

Unit-3: Artificial neural networks and extensions of regression models, regression trees. Introduction to databases, including simple relational databases.

Unit-4: Data warehouses and introduction to online analytical data processing. Association rules and prediction; data attributes, applications to electronic commerce.

References:

1.**Berson, A. and Smith, S.J. (1997).** Data Warehousing, Data Mining and OLAP. McGraw-Hill, New York.

2.**Breiman, L., Friedman, J.H., Olshen, R.A. and Stone, C.J. (1984).** Classification and Regression Trees. Wadsworth and Brooks/Cole, New York.

3.**Han, J. and Kamber,M. (2000).** Data Mining-Concepts and Techniques. Morgan Kaufmann Publishers, USA.

4.**Mitchell, T.M. (1997).** Machine Learning. Mc Graw-Hill, New York.

5.**Ripley, B.D. (1996).** Pattern Recognition and Neural Networks. Cambridge University Press, UK

STA- E15: 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: Describe the Simultaneous equation models and Approaches to econometric forecasting.

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 .

Time series econometrics: Some basic concepts, stochastic processes, unit root stochastic processes, trend stationary and difference stationary stochastic processes, integrated stochastic processes, tests of stationarity, unit root test, transforming non-stationary time series, cointegration. Approaches to economic forecasting, AR, MA, ARMA and ARIMA modeling of time series data, the Box- Jenkins methodology.

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.

STA-E16: 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;
CO5**:** Become familiar with different re-sampling techniques and use them for estimation of sampling distribution, creating confidence intervals etc.
CO6: Use EM algorithm method of finding maximum likelihood estimation when data contains missing values.

Note:- *The objective of the course is to enhance the programming skills and working knowledge of available numerical and statistical softwares. The primary need is to abreast them with the latest developments in the computing world thereby enabling them to perform data analysis effectively and efficiently in any specialized statistical software.*

Unit-I. Introduction to the statistical software R, Data objects in R, Creating vectors, Creating matrices, Manipulating data, Accessing elements of a vector or matrix, Lists, Addition, Multiplication, Subtraction, Transpose, Inverse of matrices. Read a file. Boolean operators.

Unit-II. R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Matplot, Plot options; Multiple plots in a single graphic window, Adjusting graphical parameters. Looping- For loop, repeat loop, while loop, if command, if else command.

Unit-III. Bootstrap methods: re-sampling paradigms, bias and standard errors, Bootstrapping for estimation of sampling distribution, confidence intervals, variance stabilizing transformation, bootstrapping in regression and sampling from finite populations. Jackknife and cross-validation: jackknife in sample surveys, jack-knifing in regression with hetero-sedasticity cross-validation for tuning parameters.

Unit-IV. EM algorithm: applications to missing and incomplete data problems, mixture models. Applications to Bayesian analysis, Smoothing with kernels: density estimation, simple nonparametric regression.

Text Books / References

1. **Alain F. Zuur, Elena N. Ieno, and Erik Meesters** (2009): "A Beginner's Guide to R", Springer,
2. **Michael J. Crawley** (2005): "Statistics: An Introduction using R", Wiley, ISBN 0-470-02297-3.
3. **Phil Spector** (2008): "Data Manipulation with R", Springer, New York, ISBN 978-0-387-74730-9.
4. **Maria L. Rizzo** (2008): "Statistical computing with R", Chapman & Hall/CRC, Boca Raton, ISBN 1-584-88545-9.
5. **W. John Braun and Duncan J. Murdoch** (2007): "A first course in Statistical programming with R", Cambridge University Press, Cambridge, ISBN 978-0521872652.
6. **Fishman, G.S.** (1996): Monte Carlo: Concepts, Algorithms, and Applications.(Springer).

7. **Rubinstein, R.Y.** (1981): Simulation and the Monte Carlo Method. (Wiley).
8. **Tanner, M.A.** (1996): Tools for Statistical Inference, Third edition. (Springer.)
9. **Efron, B. and Tibshirani. R.J.** (1993): An Introduction to the Bootstrap.
10. **Davison, A.C. and Hinkley, D.V.** (1997): Bootstrap Methods and their applications , Chapman and Hall.
11. **Shao J. and Tu, D.** (1995): The Jackknife and the Bootstrap. Springer Verlag.
12. **McLachlan, G.J. and Krishnan, T**. (1997) : The EM Algorithms and Extensions. (Wiley.)
13. **Simonoff , J.S.** (1996) : Smoothing Methods in Statistics. (Springer).

STA-E17: Biostatistics (4 Credits)

Course Outcomes:

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

CO1**:** Explain the need of statistics in biological areas;
CO2: Describe the basic concepts and applications of survival distributions;
CO3: Compare two survival distributions using different parametric methods;
CO4: Distinguish the concept of different types of censoring;
CO5: Estimate the survival , hazard function using parametric and nonparametric methods;
CO6: Estimate the probabilities of death under competing risk;
CO7: Describe planning and designing of clinical trials and ethics behind randomized studies involving human subjects.

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).

Text Books / References

1. **Biswas, S. (1995).** Applied Stochastic Processes. A Biostatistical and Population Oriented Approach. Wiley Eastern Ltd., New Delhi.
2. **Cox, D.R.** and **Oakes, D. (1984).** Analysis of Survival Data. Chapman & Hall, New York.
3. **Elandt, R.C.** and **Johnson (1975).** Probability Models and Statistical Methods in Genetics. John Wiley & Sons, New York.

4. **Ewens, W. J.** and **Grant, G.R. (2001).** Statistical methods in Bioinformatics: An Introduction. Springer, New York.
5. **Friedman, L.M., Furburg, C.** and **DeMets, D.L. (1998).** Fundamentals of Clinical Trials. Springer, New York.
6. **Gross, A. J.** and **Clark V.A. (1975).** Survival Distribution; Reliability Applications in Biomedical Sciences. John Wiley & Sons, New York.
7. **Lee, E. T. (1992).** Statistical Methods for Survival Data Analysis. John Wiley & Sons, New York.
8. **Li, C.C. (1976).** First Course of Population Genetics. Boxwood Press, California.
9. **Daniel, W.W.(2006).** Biostatistics: A Foundation for Analysis in the Health Sciences. John Wiley & Sons, New York.
10. **Fisher, L.D.** and **Belle, G.V. (1993).** Biostatistics: A Methodology for the Health Science. John Wiley & Sons, New York.
11. **Lawless, J.F.(2003).** Statistical Methods for Lifetime - Second Edition. John Wiley & Sons, New York.
12. **Chow, S.C. and Chang, M. (2006).** Adaptive Design Methods in Clinical Trials. Chapman & Hall/CRC Biostatistics Series, New York.
13. **Chang, M. (2007).** Adaptive Design Theory and Implementation Using SAS and R. Chapman & Hall/CRC Biostatistics Series, New York.
14. **Cox, D.R. and Snell, E.J. (1989).** Analysis of Binary Data- Second Edition. Chapman &Hall / CRC Press, New York.
15. **Hu, F. and Rosenberger, W.F. (2006).** The Theory of Response-Adaptive Randomization in Clinical Trials. John Wiley & Sons, New York.
16. **Rosenberger, W.F. and Lachin, J. (2002).** Randomization in ClinicalTrials: Theory and Practice. John Wiley & Sons, New York.

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

Audit courses:

In addition to the core and elective courses of the programme there will be two Audit Courses (Ability Enhancement Course & Professional Competency Course) with 2 credits each. These have to be done one each in the first two semesters. These courses are mandatory for all programmes but their credits will not be counted for evaluating the overall SGPA & CGPA. The Department/College shall conduct examination for these courses and have to intimate /upload the results of the same to the University on the stipulated date during the Third Semester. Students have to obtain only minimum pass requirements in the Audit Courses. The details of Audit courses are given below.

STA1A01: Ability Enhancement Course (AEC) 2 Credits

The objective of this course is to enhance the ability and skill of students in the core and elective areas of statistics, through hands on experience, internship, industrial visits, case study, community linkage, book/research paper review, scientific word processing etc.

The faculty members in the department collectively or a particular faculty member shall be in charge of this course for students of the semester, which shall be decided by the Department council. The following are the requirements in this course:-

1. Short term internships at research institutions/R&D centre/Industry.
2. Seminar presentation on a topic in statistics or related fields that is not normally covered in the in the syllabi of the programme.
3. Case study and analysis on any relevant issues in the nearby society
4. Publication of articles in statistical magazines/journals
5. Interaction with Statistical Organizations/ Industries/ Research Institutions.
6. Any community linking programme relevant to the area of study
7. Book/paper review and summary.
8. English communication skills and technical writing with LATEX.

9. Survey methodology and Data collection- sampling frames and coverage error, non-response.

10. Developing a questionnaire, collect survey data pertaining to a research problem (such as gender discrimination in private vs government sector, unemployment rates, removal of subsidy, impact on service class). Formats and presentation of reports.

After conducting the AEC, the evaluation/examination should be done either common for all students of the semester or individually depending upon the AEC conducted. Evaluation/examination on AEC must contain the following components: MCQ type written examination, Report on study/investigation, Presentation, Viva voce etc. as decided by the Department council. Evaluation/examination must be conducted as in the theory courses and the GPA and overall grade of the AEC should be determined.

STA2A02 : Professional Competency Course (PCC) 2 Credits

The objective of this course is to get professional competency and exposure in the core areas of statistics. It particularly aims to improve the skill level of students, especially for using software useful in their respective field of study, both related to the core and elective subject area. Also it is a platform for the student community to undertake socially committed statistical investigations and thereby developing a method of learning process by doing through the involvement with society.

The faculty members in the department collectively or a particular faculty member shall be in charge of this course for students of the semester, which shall be decided by the Department council. The following are the requirements in this course:-

1. Working knowledge on different statistical software/utilities like SPSS (or GNU PSPP), R, Python. (Introduction of the software- Use of the software as a calculator, as a graphing (plotting) utility, for matrix operations and for problems on probability distributions)

2. Use of Internet and other technologies - Internet and www, applications, internet protocols.

3. E-commerce and financial statistics- Electronic fund transfer, payment portal, e-commerce security.

4. Mobile commerce, Bluetooth and Wi-Fi
5. Introduction to Data Science and Big-data issues.
6. Trend Analysis (elementary time series analysis) and Index numbers
7. Official Statistics: An outline of present official statistical systems in India, Methods of collection of official statistics, their reliability and limitations, Role of MoSPI, CSO, NSSO and NSC.
8. Monte Carlo methods: Brief look at some popular approaches- simulating a coin toss, a die roll and a card shuffle.
9. CDF inversion method- simulation of standard distributions
10. Monte Carlo Integration- Basic ideas of importance sampling.

After conducting the PCC, the evaluation/examination should be done either common for all students of the semester or individually depending upon the PCC conducted. Evaluation/examination on PCC must contain the following components: MCQ type written examination, Report on study/investigation, Presentation, Viva voce etc. as decided by the Department council. Evaluation/examination must be conducted as in the theory courses and the GPA and overall grade of the PCC should be determined.

Sd/-
Dr. K. Jayakumar
Professor & Chairman, BoS in Statistics (PG)
University of Calicut