ST. JOSEPH'S COLLEGE (AUTONOMOUS), DEVAGIRI, CALICUT 8

Syllabus

for

M.Sc. STATISTICS PROGRAMME

Under

CHOICE BASED CREDIT SEMESTER SYSTEM-PG-2019

(Effective from 2019 Admissions)

M. Sc. (Statistics) Degree Programme under the Credit Semester System(CSS) for

St Joseph's College Devagiri, Calicut,
an autonomous college affiliated to the University of Calicut

Programme Structure and Syllabi

(With effect from the academic year 2019-2020 onwards)

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 Specific Outcomes:

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

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

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

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

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

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

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

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

PSO-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;

PSO-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;

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

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

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

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

Question paper pattern: For each course there shall be an external examination of duration 3 hours. The valuation shall be done by Direct Grading System. Each question paper will consists of three parts- Part-A consisting of seven short answer questions, each of weightage 2, in which four questions are to be answered; Part-B with seven paragraph answer type questions each of weightage 3, in which any four questions are to be answered and Part-C consisting of four essay type questions each of weightage 5 in which any two questions are to be answered. The questions are to be evenly distributed over the entire syllabus within each part.

SEMEMSTER 1 (CREDITS 20)				
COURSE CODE	**TITLE OF THE COURSE**	**NUMBER OF CREDITS**	**WORK LOAD HRS/WEEK**	**COURSE TYPE**
FMST1C01	Measure theory and Integration	4	5	Core
FMST1C02	Analytical tools for statistics-I	4	5	Core
FMST1C03	Analytical tools for Statistics-II	4	5	Core
FMST1C04	Sampling Theory	4	5	Core
FMST1C05	Distribution theory	4	5	Core
FMST1A01	Ability Enhancement course			Audit course

SEMEMSTER 2 (CREDITS 20)				
COURSE CODE	**TITLE OF THE COURSE**	**NUMBER OF CREDITS**	**WORK LOAD HRS/WEEK**	**COURSE TYPE**
FMST2C06	Estimation theory	4	5	Core
FMST2C07	Regression Analysis	4	5	Core
FMST2C08	Probability theory	4	5	Core
FMST2C09	Design and analysis of experiments	4	5	Core
FMST2C10	Statistical computing – I	4	5	Core
FMST1A02	Professional competency course			Audit course

SEMEMSTER 3 (CREDITS 18)				
COURSE CODE	**TITLE OF THE COURSE**	**NUMBER OF CREDITS**	**WORK LOAD HRS/WEEK**	**COURSE TYPE**
FMST3C11	Stochastic processes	5	8	Core
FMST3C12	Testing of statistical hypothesis	5	8	Core
	Elective – I	4	5	Elective
	Elective – II	4	4	Elective

SEMEMSTER 4 (CREDITS 22)				
COURSE CODE	**TITLE OF THE COURSE**	**NUMBER OF CREDITS**	**WORK LOAD HRS/WEEK**	**COURSE TYPE**
FMST4C13	Multivariate analysis	4	5	Core
	Elective - III	4	5	Elective
	Elective - IV	4	5	Elective
FMST4C14	Statistical Computing - II	4	5	Core
FMST4P01	Project	4	5	Core
FMST4V01	Viva voce	2		Core

CREDIT DISTRIBUTION (2019 ADMISSION ONWARDS)

	CORE				ELECTIVE	TOTAL
	THEORY	**PRACTICAL**	**PROJECT**	**VIVA VOCE**		
SEMESTER I	5 X 4 =20					**20**
SEMESTER II	4 X 4 =16	1 X 4 =4				**20**
SEMESTER III	2 X 5 =10				2 X 4 =8	**18**
SEMESTER IV	1X 4 = 4	1 X 4 = 4	1 X 4 = 4	1 X 2= 2	2 X 4 =8	**22**
TOTAL	**50**	**8**	**4**	**2**	**16**	**80**

ABILITY ENHANCEMENT COURSE (AEC)

Successful fulfillment of any one of the following shall be considered as the completion of AEC. (i) Internship, (ii) Class room seminar presentation, (iii) Publications, (iv) Case study analysis, (v) Paper presentation, (vi) Book reviews. A student can select any one of these as AEC.

Internship: Internship of duration 5 days under the guidance of a faculty in an institution/department other than the parent department. A certificate of the same should be obtained and submitted to the parent department.

Class room seminar: One seminar of duration one hour based on topics in statistics beyond the prescribed syllabus.

Publications: One paper published in conference proceedings/ Journals. A copy of the same should be submitted to the parent department.

Case study analysis: Report of the case study should be submitted to the parent department.

Paper presentation: Presentation of a paper in a regional/ national/ international seminar/conference. A copy of the certificate of presentation should be submitted to the parent department.

Book Reviews: Review of a book. Report of the review should be submitted to the parent department.

PROFESSIONAL COMPETENCY COURSE (PCC)

A student can select any one of the following as Professional Competency course:

1. Technical writing with $L^{A}T_{E}X$.
2. Statistical data analysis using SPSS
3. Scientific Programming with Python.

SYLLABI OF COURSES OFFERED IN SEMESTER I

FMST1CO1: MEASURE THEORY AND INTEGRATION

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Students will be able to understand the basic concepts of measure and integration theory.
CO2: Help learners for understanding the theoretical basis of probability and statistics.
CO3: Help learners to understand the theory on the basis of examples of application.
CO4: Students will be able to use abstract methods to solve problems and cultivate ability to use a wide range of references and critical thinking.

Unit I: Measure spaces, Measurable functions σ-algebra of subsets of sets, measure spaces, measurable functions and their combinations, simple functions, non-negative measurable functions as limit of simple functions, integral of a simple function, integral of a non negative measurable function. The monotone convergence theorem, Fatou's Lemma.

Unit II: Integrable functions. Integrable real valued functions, Lebesgue dominated convergence theorem, integral which depend on a parameter, normed linear spaces, Lp spaces, Holder's inequality, Minkowski's inequality

Unit III: Modes of convergence. Decomposition of measures, extension of measures. The Hahn Decomposition theorem, The Jordan decomposition, Radan-Nikodym theorem and Lebsgue de- composition theorem.

Unit IV: Measures on an algebra of sets, Caratheodory extension theorem, Lebesgue and Lebesgue- Stieltjes measure,Product measures and product squares, rectangles, sections, monotone class lemma, Tonill's and Fubini's theorem.

Text books

1. **Robert G Bartil**, (1995) Elements of integration and lebesgue measure, John Wiley & sons, New York

Reference books

1. **Royden.H.L**, (2004) Real analysis (third edition), McMillain publishing company, New York.
2. **Frank Burk**,(1998), Lebesgue measure and integration an introduction, John Wiley and sons

FMST1CO2: ANALYTICAL TOOLS FOR STATISTICS - I

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Student will get a good exposure to the basic and some relevant advanced concept in maths.

CO2:To acquire in depth knowledge in the convergence of sequence of function and series of function.

CO3: Understanding the application of Mean value theorem and Taylors Theorem.

Unit I: Finite countable and uncountable sets, metric spaces, compact set, Bolzano weirstrass theorem. perfect set, connected set.

Unit II: limit of functions, continuous function, continuity and compactness, continuity and connectedness, discontinuities, monotone functions, derivative of a real valued function, mean value theorem, Derivatives of higher order. Taylor's theorem

Unit III: Reimann-Stieltjes integral, Definitions, existence and properties of Reimann-Stieltjes integral, Integration and differentiation.

Unit-IV: Sequences and Series of Functions, pointwise and uniform convergence. uniform convergence and continuity , uniform convergence and integration, uniform convergence and differentiation. Weirstrass theorem.(From text 1)

Text books

1. **Rudin. W.** Principles of real analysis, Mcgraw-hill (1976)
2. **Andre's I. Khuri**(1993) Advanced Calculus with applications in statistics. Wiley & sons (Chapter 7)

Reference books

1. **Apsostol, T.M.** (1974): Mathematical Analysis, Second edition Norosa, New Delhi.
2. **Malik, S.C & Arora.S** (2006): Mathematical analysis, second edition, New age international
3. **John D Depree and Charles W Swartz**, (2014), Introduction to real analysis, John Wiley and sons

FMST1CO3: ANALYTICAL TOOLS FOR STATISTICS - II

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Student will be able to use computational techniques and algebraic skills essential for the study of system of linear equations,matrix algebra, vector spaces, eigenvalues and eigen vectors, orthoganality and diagonalisation.

CO2: Critically analyze and construct mathematical arguments that related to the study of introductory linear algebra.

Unit I: Basics of linear algebra Definition of a vector space, sub spaces, linear dependence and indepen- dence, basis and dimensions, direct sum and compliment of a subspace, caution spaces, inner product and orthogonality.

Unit 2: Algebra of Matrices Linear transformations and matrices, operations on matrices, properties of matrix operations, Matrices with special structures - triangular matrix, idempotent matrix, Nilpotent matrix, symmetric Hermitian and skew Hermitian matrices unitary matrix. Row and column space of a matrix, inverse of a matrix. Rank of product of matrix, rank factorization of a matrix, Rank of a sum and product, Inverse of a partitioned matrix, Rank of real and complex matrix, Elementary operations and reduced forms.

Unit 3: Eigen values, Cayley-Hamilton theorem, minimal polynomial, eigen values and eigen spaces, spectral representation of a semi simple matrix, algebraic and geometric multiplicities, Jordan canonical form, spectral representation of a real symmetric, Hermitian and normal matrices, singular value decomposition.

Unit 4: Linear equations generalized inverses and quadratic forms Homogenous system, general system, Rank Nullity Theorem, generalized inverses, properties of g-inverse, Moore-Penrose inverse, properties, com- putation of g-inverse, definition of quadratic forms, classification of quadratic forms, rank and signature, positive definite and non-negative definite matrices, extreme of quadratic forms, simultaneous diagonalization of matrices

Text books

1. **Ramachandra Rao and Bhimashankaran (**1992).Linear Algebra Tata McGraw hill
2. **Lewis D.W** (1995) Matrix theory, Allied publishers, Bangalore.

Reference books

1. **Suddhendu Biswas** (1997) A text book of linear algebra, New age international.
2. **Rao C.R** (2002) Linear statistical inference and its applications, Second edition, John Wiley and Sons, New York.
3. **Graybill F.A** (1983) Matrices with applications in statistics.
4. **Sheldon Axler(2014),** Linear algebra done right, 3rd edition, Springer

FMST1CO4 : SAMPLING THEORY

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Demonstrates a structure to data collection.

CO2: The learners will get an idea on how to make a representative sample to avoid bias and the necessity of sampling in statistics.

CO3: The learners will be familiar with different sampling techniques such as srs, systematic, stratified and cluster sampling.

CO4: The learners will be able to obtain an estimate of population parameter using sample information under different sampling techniques.

CO5: Students will be able to use auxiliary information to improve the sampling plan or to enhance estimation of the variable of interest.

CO6: Introduce multistage and multiphase sampling.

Unit-I: Census and Sampling-Basic concepts, probability sampling and non-probability sampling, simple random sampling with and without replacement- estimation of population mean and total-estimation of sam- ple size- estimation of proportions. Systematic sampling linear and circular systematic sampling-estimation of mean and its variance- estimation of mean in populations with linear and periodic trends.

Unit-II: Stratification and stratified random sampling. Optimum allocations , comparisons of variance under various allocations. Auxiliary variable techniques. Ratio method of estimation-estimation of ratio, mean and total. Bias and relative bias of ratio estimator. Mean square error of ratio estimator. Unbiased ratio type estimator. Regression methods of estimation. Comparison of ratio and regression estimators with simple mean per unit method. Ratio and regression method of estimation in stratified population.

Unit-III: Varying probability sampling, pps sampling with and without replacements. Des- Raj ordered estimators, Murthy's unordered estimator, Horwitz-Thompson estimators, Yates and Grundy forms of vari- ance and its estimators, Zen-Midzuno scheme of sampling, PPS sampling.

Unit-IV: Cluster sampling with equal and unequal clusters. Estimation of mean and variance, relative efficiency, optimum cluster size, varying probability cluster sampling. Multi stage and multiphase sampling. Non-sampling errors.

Text books

1. **D. Singh and F.S. Chowdhary** (2018): Theory and Analysis of Sample Survey Designs, Wiley Eastern (New Age International), NewDelhi.

Reference books

1. **Cochran W.G** (1992): Sampling Techniques, Wiley Eastern, New York.
2. **P.V.Sukhatme , B V Sukhatme, S Sukhatme and C Asok** (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.
3. **Parimal Mukhopadhyay**, (2009), Theory and methods of survey sampling,2nd edition, PHI

learning Pvt ltd

FMST1CO5: DISTRIBUTION THEORY

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Introduce several discrete distributions and their important characteristics.
CO2: Introduce several continuous distributions and their important characteristics.
CO3: Exploring the relationship between different distributions using Jacobian transformation, characteristic functions and limit theorems.
CO4: To study various sampling distributions and their properties.

Unit- 1: Discrete distributions Random variables , Moments and Moment generating functions, Probabil- ity generating functions, Discrete uniform, binomial, Poisson, geometric, negative binomial, hyper geometric and Multinomial distributions, power series distributions.

Unit- 2: Continuous distributions Uniform , Normal, Exponential, Weibull, Pareto, Beta, Gama, Laplace, Cauchy and Log-normal distribution. Pearsonian system of distributions, location and scale families.

Unit-3: Functions of random variables. Joint and marginal distributions, conditional distributions and independence, Bivariate transformations, covariance and correlations, bivariate normal distributions, hi- erarchical models and mixture distributions, multivariate distributions, inequalities and identities. Order statistics.

Unit -4: Sampling distributions Basic concept of random sampling, Sampling from normal distributions, properties of sample mean and variance. Chi-square distribution and its applications, t-distribution and its applications. F-distributions- properties and applications. Noncentral Chi-square, t, and F-distributions.

Text books

1. **Rohatgi, V.K. and Md Ehsanes Saleh** (2015).Introduction to probability and statistics. John Wiley and sons.
2. **George Casella and Roger L. Berger**(2003). Statistical Inference. Wodsworth & brooks Pacefic Grove, California

Reference books

1. **Johnson ,N.L.,Kotz.S. and Balakrishnan, N.(**1995). Continuous univariate distributions, Vol.I & Vol.II, John Wiley and Sons, New York.
2. **Johnson ,N.L.,Kotz.S. and Kemp.A.W**.(1992).Univariate Discrete distributions, John Wiley and Sons, New York.
3. **Kendall, M. and Stuart, A.** (1977). The Advanced Theory of Statistics Vol I: Distribution Theory, 4th Edition

SYLLABI OF COURSES OFFERED IN SEMESTER-II
FMST2CO6: ESTIMATION THEORY

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To explain clearly the role of sufficient statistic in estimation.
CO2: Discuss desirable properties of good estimators such as unbiasedness , efficiency, consistency and asymptotic normality.
CO3: Describing various methods of estimation.
CO4: Suggesting interval estimates for various population parameters.

Unit-1: Sufficient statistics and minimum variance unbiased estimators. Sufficient statistics, Factorization theorem for sufficiency (proof for discrete distributions only), joint sufficient statistics, exponential family, minimal sufficient statistics, criteria to find the minimal sufficient statistics, Ancillary statistics, complete statistics, complete statistics, Basu's theorem (proof for discrete distributions only), Unbiasedness, Best Linear Unbiased Estimator(BLUE), Minimum Variance Unbiased Estimator (MVUE), Fisher Information, Cramer Rao inequality and its applications, Rao-Blackwell Theorem, Lehmann- Scheffe theorem, necessary and sufficient condition for MVUE.

Unit-2: Consistent Estimators and Consistent Asymptotically Normal Estimators. Consistent estimator, Invariance property of consistent estimators, Method of moments and percentiles to determine consistent estimators, Choosing between consistent estimators, Consistent Asymptotically Normal (CAN) Estimators.

Unit-3: Methods of Estimation. Method of moments, Method of percentiles, Method of maximum likelihood (MLE), MLE in exponential family, One parameter Cramer family, Cramer-Huzurbazar theorem,Bayesian method of estimation.

Unit-4: Interval Estimation. Definition, Shortest Expected length confidence interval, large sample confidence intervals, Unbiased confidence intervals, Bayesian and Fiducial intervals.

Text book

1. **Kale,B.K.(**2005). A first course in parametric inference, Second Edition, Narosa Publishing House, New Delhi.
2. **George Casella and Roger L Berger** (2002). Statistical inference, Second Edition, Duxbury, Australia.

Reference books

1. **Lehmann E.L** (1998). Theory of point estimation, Second edition, John Wiley and sons, New York.
2. **Rohatgi, V.K. and Md Ehsanes Saleh** (2015).Introduction to probability and statistics. John Wiley and sons.
3. **Rohatgi V.K** (1984). Statistical Inference, John Wiley and sons, New York.
4. **Rao C.R** (2002). Linear Statistical Inference and its applications, Second Edition, John Wiley and sons, New York.

FMST2CO7: REGRESSION ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Develop a deeper understanding of the linear regression model and its limitations.

CO2: Know how to diagnose and apply corrections to some problems with the generalized linear model found in real data.

CO3:Use and understand generalization of the linear model to binary and count data.

Unit 1: Simple linear regression, Least square estimation of parameters, Hypothesis testing for the slope and intercept, confidence intervals, interval estimation of the mean response, prediction of new observation, coefficient of determination, Estimation by maximum likelihood

Unit 2: Linear models Gauss Markov linear model-estimibality of parametres, Gauss markov theorem, Properties of least square estimators, estimation of σ^2, inference on regression parameters, Residual analysis, model checking, Transformations and weighting to correct model inadequacies

Unit 3: Polynomial regression models, Polynomial models in one variable , non-parametric regression, Kernel regression, locally weighted regression, orthogonal polynomials, Indicator variables, variable selection and model building

Unit 4: Introduction to non-linear regression , linear and non-linear regression models, non-linear least squares, transformation to linear models, parameter estimation in a non-linear system. Generalised regression models Logistic regression model, Poisson regression model, generalized linear model,linkfunction and linear predictors. Parametric estimation and inference on GLM, prediction and estimation in GLM,residual analysis in GLM, overdispersion.

Textbooks

1. **Douglas c Montgomery**, **Elizabeth A Peck and G. Geoffrey Vining**, Introduction to regression analysis , 3rd edition, John Wiley and sons
2. **Joshi D.D,**Linearestimation,(1983),Linear estimation and design of experiment. Wiley Eastern, NewDelhi.

Referencebooks

1. **Draper S.R. and Smith H**(1986),Applied regression analysis, Third edition, Wiley Newyork.
2. **Chatterjee S and PriceB**(1977)Regression analysis by examples, Wiley NewYork
3. **B Abraham and Ledolter J** (2006),Introduction to regression modeling, Thompson and Brooksm USA.
4. **Seber.A.F and Lee A.J**(2003),Linear regression analysis, Wiley, NewYork

FMST2CO8: PROBABILITY THEORY

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Understand the axiomatic formulation of modern probability theory and think of random variable as an intrinsic need for the analysis of random phenomena.

CO2: Studying various characteristics of random variables using moments, moment generating functions and inequalities.

CO3:Studying different types of convergence of random variables and their application to law of large numbers and centeral limit theorem.

Unit 1: Probability space, distribution function, independence. Axiomatic approach to probability, dis- tribution functions, independence of events and random variables, Borel 0-1 Law, Kolmogorov 0-1 law.

Unit 2: Convergence of random variables and law of large numbers. Convergence in probability, almost sure convergence, convergence in distribution, convergence in rth mean, weak law of large numbers, strong law of large numbers.

Unit 3: Characteristic function and central limit theorem Definition of a characteristic function, ele- mentary properties, characteristic functions and moments, moment problem. Inversion theorem, Helly-Bray theorem and continuity theorem, central limit theorem of Lindberg Levi, Liaponov and Lindberg-Feller theorem.(Proof of Lindberg-feller theorem not required)

Unit 4: Conditional expectations and martingale. Definition and properties of conditional expectations, Radan-Nikodym theorem, Martingale, super and sub martingale, Doob decomposition, stopping times, Mar- tingale limits theorems.

Text books

1. **B.R Bhat** (1999), Modern Probability theory, Wiley Eastern
2. **Laha & Rohatgi**(19 79), Probability theory, Wiley New York

Reference books

1. **Patrick Billingsley**(1995), Probability and measure, Wiley New York
2. **Galambos** (1988), Advanced probability theory, Marcel Dekar, New York

FMST2CO9: DESIGN AND ANALYSIS OF EXPERIMENTS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Introduce the theory of linear estimation and its application to the analysis of experimental designs.

CO2: Make use of the basics of the Design of Experiments such as randomization blocking and local control.

CO3: Identify commonly used designs such as RBD,LSD,GLSD,BIBD,PBIBD and various factorial designs and their construction.

CO4: Perform an appropriate statistical analysis of different types of designs.

Unit- 1: Linear Model, Estimable Functions and Best Estimate, Normal Equations, Sum of Squares, Distribution of Sum of Squares, Estimate and Error Sum of Squares, Test of Linear Hypothesis, Basic Principles and Planning of Experiments, Experiments with Single Factor-ANOVA, Analysis of Fixed Effects Model, Model Adequacy Checking, Choice of Sample Size, ANOVA Regression Approach, Non parametric method in analysis of variance, Kruskell-Wallis Test.

Unit- 2: Complete Block Designs, Completely Randomized Design, Randomized Block Design, Latin Square Design, Greaco Latin Square Design, Analysis with Missing Values, ANCOVA,

Unit- 3: Incomplete Block Designs-BIBD, Recovering of Intra Block Information in BIBD, Construction of BIBD, PBIBD, Youden Square, Lattice Design.

Unit- 4: Factorial Designs-Basic Definitions and Principles, Two Factor Factorial Design-General Facto- rial Design, 2^k Factorial Design-Confounding and Partial Confounding, 3^2-factorial, Asymmetric factorial, Two Level Fractional Factorial, Split Plot Design.

Text books

1. **Joshi D.D**. (1987): Linear Estimation and Design of Experiments. Wiley Eastern Ltd., New Delhi.
2. **Montgomery D.C.** (2001): Design and Analysis of Experiments. 5th edition, John Wiley & Sons-New York.

Reference books

1. **Das M.N. & Giri N.S.** (2002): Design and Analysis of Experiments. 2nd edition , New Age International (P) Ltd., New Delhi.
2. **Angola Dean & Daniel Voss** (1999): Design and Analysis of Experiments. Springer-Verlag, New York.

FMST2C10: STATISTICAL COMPUTING-I (Practical Course)

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To develop sceintific and experimental skills of the students and to correlate the theoretical principles with application based studies.

CO2: The learners will be familiarize with R software.

Teaching scheme: 5 hours practical per week. Statistical Computing-I is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the following FIVE courses of the first and second semesters.

1. :Regression Analysis
2. Distribution Theory
3. Estimation Theory
4. Sampling Theory
5. Design and Analysis of Experiments

Practical is to be done using R programming / R software. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination. Students are expected to acquire working knowledge of the statistical package - EXCEL. The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at the center shall be conducted and evaluated on the same day jointly by two examiners - one external and one internal. The question paper for the external examination at the center will be set by the external examiner in consultation with the H/D of the center. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

SYLLABI OF COURSES OFFERED IN SEMESTER-III
FMST3C11 : STOCHASTIC PROCESSES

Lecture Hours Per Week:8 Credits:5

Course Outcomes

CO1: The student will be familiar with the concept of the stochastic process, which describes many phenomena that involve random situations. He / she will be able to make various calculations and make the appropriate conclusion when the stochastic process describes a particular applied problem.

CO2: Markov process, one of the most important topic in stochastic process will become familiar to the students and they will become capable of applying this into queueing theory, inventory management, branching process.

CO3: Student will get a thorough exposure in Poisson process and its extensions.

Unit-1: Concept of Stochastic processes, examples, Specifications; Markov chains- Chapman Kolmogorov equations - classification of states - limiting probabilities; Gamblers ruin problem and Random Walk, Branch- ing processes (discrete time).

Unit-2: 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.

Unit-3: Continuous time Markov Chains - Birth and death processes - transition probability function- limiting probabilities. Renewal processes-limit theorems and their applications. Renewal reward process, regenerative processes, semi-Markov process.

Unit-4: 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. 4th Edition, Academic Press.
2. **Medhi, J.** (1996): Stochastic Processes. Second Editions. Wiley Eastern, New-Delhi.

References

1. **Karlin, S. and Taylor, H.M.** (1975): A First Course in Stochastic Processes. Second Edition Academic Press. New-York.
2. **Cinlar, E.** (1975): Introduction to Stochastic Processes. Prentice Hall. New Jersey.
3. **Basu, A.K.** (2003): Introduction to Stochastic Processes. Narosa, New-Delhi.

FMST3C12: TESTING OF STATISTICAL HYPOTHESES

Lecture Hours Per Week:8 Credits:5

Course Outcomes

CO1: Familiarize students with the Neymann-Pearson approach to testing of hypothesis.
CO2: Expertise students in constructing various nonparametric tests.
CO3:Examines various aspects of SPRT including its need , construction and implementation.

Unit-1: Tests of hypotheses and Most Powerful Tests: Simple versus simple hypothesis testing problem - Error probabilities, p-value and choice of level of significance - Most powerful tests - Neyman Pearson Lemma one-sided UMP tests, two sided UMP tests and UMP unbiased tests.

Unit-2: UMP test for multi-parameter case: UMP unbiased test, α-similar tests and α-similar tests with Neyman structure, construction of α-similar tests with Neyman structure. Principle of invariance in testing of hypotheses, locally most powerful tests - Likelihood ratio tests - Bayesian tests .

Unit-3: Non-parametric Tests: Single sample tests - testing goodness of fit, Chi-square tests- Kolmogorov- Smirnov test - sign test - Wilcoxon signed rank test. Two sample tests - the chi-square test for homogeneity

- Kolmogorov - Smirnov test; the median test - Mann- Whitney-Wilcoxon test - Test for independence - Kendall's tau - Spearman's rank correlation coefficient - robustness.

Unit-4: Sequential Tests: Some fundamental ideas of sequential sampling - Sequential Probability Ratio Test (SPRT) - important properties, termination of SPRT - the fundamental identity of SPRT - Operating Characteristic (OC) function and Average Sample Number (ASN) of SPRT - Developing SPRT for different problems .

Text Books

1. **Casella, G. and Berger, R.L.** (2002): Statistical Inference, Second Edition Duxbury, Australia.
2. **Rohatgi, V.K. and Md Ehsanes Saleh** (2015).Introduction to probability and statistics. John Wiley and sons.
3. **Manojkumar Srivastava and Namita Srivstava** (2009): Statistical Inference: Testing of Hypothesis, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.

References

1 **Fraser, D.A. S.** (1957): Non - parametric Methods in Statistics, Wiley, New York.
2. **Lehman, E.L. and Joseph P Romano** (1991): Testing of Statistical Hypotheses. 3rd edition, Springer
3. **Forguson, T.S**. (1967): Mathematical Statistics: A Decision - Theoretic Approach. Academic Press, New York.
4. **Wald, A.** (1947): Sequential Analysis, Wiley, New York.
5. **Dudewicz, E.J. and Mishra, S.N.** (1988): Modern Mathematical Statistics, John Wiley & Sons, New York.

FMST3E.... - -: ..... (Elective-I) (4 Credits)
(to be selected from the approved list of Electives) .

FMST3E.... -: ..... (Elective-II) (4 Credits)
(to be selected from the approved list of Electives)

SYLLABI OF COURSES OFFERED IN SEMESTER-IV
FMST4C13: MULTIVARIATE ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To study various aspects of multivariate normal density.

CO2: To derive maximum likelyhood estimates of various parameters and their sampling distributions.

CO3: To create various test procedures and their implementation.

CO4: Introduce and analyse some special techniques such as principle component analysis, factor analysis and canonical correlation.

Unit-1: Multivariate Normal Distribution - Definition and 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-2: 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. Distribution of simple, partial and multiple (null-case only) correlation coefficients; canonical correlation. Wishart distribution - properties - generalized variance.

Unit-3: Testing Problems - Mahalanobis D2 and Hotelling's T2 Statistics, Likelihood ratio tests - Test- ing the equality of mean vector, equality of dispersion matrices, testing the independence of sub vectors, sphericity test.

Unit-4: 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. Pop- ulation principal components - Summarizing sample variation by principal components - Iterative procedure to calculate sample principal components; Factor analysis.

Text Books

1. **Anderson, T.W.** (1984): Multivariate Analysis. John - Wiley, New York.
2. **Johnson, R.A. and Wichern, D.W**. (2001): Applied multivariate statistical analysis, 3rd Edn., Prentice Hall of India, New Delhi.
3. **Rao, C.R**.(2002): Linear Statistical Inference and Its Applications, Second Edition, John Wiley and Sons, New York.

References

1. **Giri, N.C**. (1996): Multivariate Statistical Analysis. Marcel Dekker. Inc., New York.
2. **Kshirasagar, A.M.** (1972): Multivariate Analysis. Marcel Dekker. New-York
3. **Rencher, A.C.** (1998): Multivariate Statistical Analysis. Jon Wiley, New York.
4. **Morrison, D.F.** (1976): Multivariate statistical methods, McGraw Hill, New York.

FMST4E...(Elective-III)(4Credits)
(to be selected from the approved list of Electives).

FMST4E...(Elective-IV)(4Credits)
(to be selected from the approved list of Electives).

FMST4P01: PROJECT/DISSERTATION

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To help them how to practically design a sampling procedure and conduct a survey.
CO2:To get a training in analyzing the data so collected making use of a software.
CO3: To make a relevant conclusion based on the analysis of the data.

In partial fulfillment of the M.Sc. programme, 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 before the deadline suggested in the Academic calendar. The project/ dissertation is of 4 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, based on a well defined scheme of valuation framed by them, under direct grading system.

FMST4C14: STATISTICAL COMPUTING-II (Practical Course)

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To develop sceintific and experimental skills of the students and to correlate the theoretical principles with application based studies.

CO2: The learners will be familiarize with R software.

Teaching scheme: 5 hours practical per week. Statistical Computing-II is a practical course. Its objectives are to develop scientific and experimental skills of the students and to correlate the theoretical principles with application based studies. The practical is based on the core and elective courses of the third and fourth semesters. Practical is to be done using R programming / R software. At least five statistical data oriented/supported problems should be done from each course. Practical Record shall be maintained by each student and the same shall be submitted for verification at the time of external examination. The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination.

The external examination at the center shall be conducted and evaluated on the same day jointly by two examiners - one external and one internal. The question paper for the external examination at the center will be set by the external examiner in consultation with the H/D of the center. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assessing each candidate on the scientific and experimental skills, the efficiency of the algorithm/program implemented, the presentation and interpretation of the results. The valuation shall be done by the direct grading system and grades will be finalized on the same day.

FMST4 V01: VIVA-VOCE

Credits:2

Course Outcomes

CO1: To give students a practice in facing an interview.

CO2: To let them know how much they have understood from each course.

The External Viva-Voce shall be conducted by a Board of Examiners, consisting of at least one external expert. The external viva-voce shall cover all the courses undergone in the programme. The evaluation shall be done by the direct grading system.

LIST OF ELECTIVES

1. **E01:** Operations Research
2. **E02**: Econometric Models
3. **E03:** Statistical Quality Control
4. **E04**:Abstract Algebra
5. **E05:** Advanced Probability
6. **E06:** Biostatistics
7. **E07:** Official Statistics
8. **E08:** Statistical Ecology and Demography
9. **E09:** Longitudinal Data Analysis
10. **E10**: Generalized Linear Models
11. **E11:**TimeSeries Analysis
12. **E12:**Computer Oriented Statistical Methods
13. **E13:** Statistical decision theory & bayesian analysis
14. **E14:**Reliability Modeling
15. **E15:** Lifetime Data Analysis

E01: OPERATIONS RESEARCH

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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.

Module 1 : Introduction to linear programming problem, Graphical solution, Simplex method ,Big-M method and two phase simplex method, Revised simplex method, Dual of a linear programming problem, Weak duality theorem, Fundamental theorem of duality, Dual simplex method, Sensitivity analysis.

Module 2 : Integer programming problem, Gomery's cutting plane method and Branch and bound method, Transportation problem, Assignment problem, Game theory, Pure and mixed strategies, Graphical solution to m x 2 and 2 x n games, Conversion of rectangular game in to an LPP, Fundamental theorem of games.

Module 3 : Classical optimization theory, unconstrained problems, necessary and sufficient condition, Constrained problems-Jacobian method Legrangian method, Inequality constraints, Kuhn Tucker conditions, Non linear programming algorithms, Direct search (dichotomous and golden selection method), Gradient method, Separable programming, Quadratic programming

Module 4 : Inventory models, deterministic inventory EOQ models, EOQ with one and two price breaks, Probabilistic inventory models, discrete and continuous models, Network models: Introduction, minimal spanning tree algorithm ,shortest route problem, maximal flow models, CPM and PERT

References:

1. **Hadley G** (1964)Linear programming, Oxford and IBH publishing co., New Delhi
2. **Kanthiswaroop, P K Gupta and Manmohan**,(1999) Operations research , S. Chand publishers
3. **H A Taha(**2007), Operations research: an introduction , 8th edition, Pearson
4. **Hiller F.S and Lieberman, G.J**(1995), Introduction to operations research, McGrow Hill, New York

E02 : ECONOMETRIC MODELS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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.

Unit-1: 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-2: 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-3: Meaning and methodology of econometrics, regression function, multiple regression model, as- sumptions, 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.

Unit-4: Dynamic econometric models: Auto regressive and distributed lag- models, estimation of dis- tributed lag- models, Koyck approach to distributed lag- models, adaptive expectation model, stock adjust- ment 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. Simultaneous equation models: examples, inconsistency of OLS estimators, identification problem, rules for identification, method of indirect least squares, method of two stage least squares .

Text Books

1. . **Alpha C Chiang** (1984): Fundamental Methods of Mathematical Economics (Third edition), McGraw -Hill, New York.
2. . **Damodar N Gujarati** (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. **Taro Yamane** (1968): Mathematics for Economists an elementary survey (second edition), Prentice- Hall, India.

E03: STATISTICAL QUALITY CONTROL

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Understanding of the link between SQC and business analysis or business planning .

CO2: Understand the philosophy and basic concepts of quality improvement.

CO3: Demonstrates the ability to use the methods of statistical process control.

CO4: Demonstrates the ability to design, use and interpret control charts for attributes and variables.

Unit-1: Statistical process control, theory of control charts, Shewhart control charts for variables $\bar{x}$, R, s charts, p,np, c, u charts, modified control charts.

Unit-2: O.C and ARL curves of control charts, moving average control charts, EWMA charts, CUSUM charts, process capability analysis, process capability indices.

Unit-3: Acceptance sampling for attributes, single sampling, double sampling, multiple sampling and sequential sampling plans, rectifying inspection plans, measuring performance of the sampling plans-OC, AOQ, ASN, ATI curves.

Unit.4: 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 and III.

Text Books

1. . **Montgomory, D.C.** (2005), Introduction to Statistical Quality Control. 5th edition. Wiley, New-York.
2. **Gerant, E.L. and Leaven Worth, R.S.** (1980). Statistical Quality Control. Mc-Graw Hill

References

1. **Mittage, H.J. and Rinne, H.** (1993).Statistical Methods for Quality Assurance. Chapman and Hall.
2. **Oakland, J.S. and Follorwel, R.F.** (1990). Statistical Process Control. East-West Press.
3. **Schilling, E.G.** (1982).Acceptance Sampling in Quality Control. Marcel Dekker.
4. **Chin-Knei Chao** (1987). Quality Programming, John Wiley.
5. **Ott, E.R.** (1975): Process Quality Control; McGraw Hill.

E04: ABSTRACT ALGEBRA

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Student will get a good exposure to the basic and some relevant advanced concept in maths.

CO2:To acquire in depth knowledge in the area of group, ring and field.

CO3: Understanding the application of Sylow theorems.

Module -1(Sections 4,5,6,8,9,10,11 . Omit the sections 6.3,6.4,6.5,6.8,6.9) Groups, Subgroups, Cyclic groups, Groups of permutation(Upto Cayley's Theorem)- Orbits, Cycles and the alternating groups(omit all proofs)- Cosets and theorem of Lagrange- Direct products and finitely generated abelian groups(omit all proofs).

Module 2(Sections 13,14,15,34,36,37) Homomorphism- Factor groups, factor group computation and sim- ple groups (omit all proofs)- Isomorphism theorems, Sylow theorems (omit all proofs)- Applications of Sylow theorems

Module 3(Sections 18,19,22,23) Rings and fields, Integral domains (omit all proofs)- Rings of polynomials, factorization of polynomials over a field(omit proofs of 22.2, 22.4)

Module 4(Sections 26,27,29,31,33 omit the proofs of all theorems) Homomorphisms and factor rings, prime and maximal ideals, introduction to extension fields, algebraic extensions, finite fields.

Text book :

1) **John B. Fraleigh**, A First course in Abstract Algebra, Seventh Edition, Pearson education

References

1. **Durbin** (1986). Modern Algebra, An Introduction, 5th Edition Wiley.
2. **Joseph A Gelion** (1980). Contempary Abstract Algebra, Narosha Publication.
3. **P.B.Bhattacharya, S.K. Jain & S.R. Nagpaul** (1991). Basic Abstract Algebra, 2nd Edition , Cambridge University Press.

E05: ADVANCED PROBABILITY

Lecture hours Per Week:5 Credit:4

Course Outcomes

CO1: Understand the axiomatic formulation of modern probability theory and think of random variable as an intrinsic need for the analysis of random phenomena.

CO2: Studying various characteristics of random variables using moments, moment generating functions and inequalities.

CO3:Studying different types of convergence of random variables and their application to law of large numbers and centeral limit theorem

Unit-1: Review of Elementary Probability theory, Basic properties of expectations, Sequences of Integrals, Lebesgue-Stieltjes integrals, Convergence Concepts, Weak convergence - Theorems.

Unit-2: Complete convergence: Kolmogorov's three-series and two series theorems, Decomposition of Normal distribution, Levy's metric, Zolotarev and Lindeberg - Feller Theorems; Berry - Esseen Theorem.

Unit-3: Infinite Divisibility of Probability Distributions: Infinitely Divisible Distribution on (i) The Non-Negative Integers.(ii) The Non-Negative Reals. Triangular arrays of independent random variables - Convergence under UAN, Convergence to special distributions, Stable distributions.

Unit-4: Conditional expectations (general case) - definition and properties, Random-Nikodyn theorem, Martingales, super/sub-martingales, Doob's decomposition, stopping times, Martingale limit theorems, In- troduction to Martingales in continuous time, path properties and examples; Exchangeability, DeFenneti's theorem.

Text Books

1. **Galambos J** (1988): Advanced Probability Theory, Marcel Dekker, New York
2. **Resnick, S.I.** (1999): A Probability Path, Birkhauser, Boston. Steutel, F.W. and van Harn, K. (2004). Infinite Divisibility of Probability Distributions on the Real Line. Marcel Dekker Inc., New York.

References

1. **Ash R. B** (2000): Probability and Measure Theory, 2nd edition. Academic Press.
2. **Billingsley P** (1985): Probability and Measure, 2nd edition, John Wiley and Sons, NewYork.
3. **Laha R.G. and Rohatgi, V.K.** (1979): Probability Theory, John Wiley and Sons, NewYork.
4. **Billingsley, P**. (1979): Probability and Measure, 3/e, Wiley, New York.
5. **Brieman, L**.(1968): Probability, Addison-Wesley.

E06: BIOSTATISTICS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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;

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-2: 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-3: 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-4: Basic biological concepts in genetics, Mendel's law, Hardy- Weinberg equilibrium, random mat- ing, 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. Plan- ning 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.
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.: An Introduction, Springer.
5. **Friedman, L.M., Furburg, C. and DeMets, D.L.** (1998): Fundamentals of Clinical Trials, Springer Verlag.
6. **Gross, A. J. and Clark V.A.** (1975): Survival Distribution; Reliability Applications in Biomedical Sciences, John Wiley & Sons.

7. **Lee, Elisa, T.** (1992): Statistical Methods for Survival Data Analysis, John Wiley & Sons.
8. **Li, C.C.** (1976): First Course of Population Genetics, Boxwood Press.
9. **Daniel, W.W.(**2006): Biostatistics: A Foundation for Analysis in the Health sciences, John Wiley & sons.Inc.
10. **Fisher, L.D. and Belle, G.V.** (1993): Biostatistics: A Methodology for the Health Science, John Wiley & Sons Inc.
11. **Lawless, J.F**.(2003): Statistical Methods for Lifetime (Second Edition), John Wiley & Sons.
12. **Chow, Shein-Chung and Chang, Mark** (2006): Adaptive Design Methods in Clinical Trials. Chapman & Hall/CRC Biostatistics Series.
13. **Chang, Mark** (2007): Adaptive Design Theory and Implementation Using SAS and R. Chapman & Hall/CRC Biostatistics Series.
14. **Cox, D.R. and Snell, E.J.** (1989): Analysis of Binary Data, Second Edition. Chapman & Hall / CRC Press.
15. **Hu, Feifang and Rosenberger, William** (2006): The Theory of Response-Adaptive Randomization in Clinical Trials. John Wiley.
16. **Rosenberger, William and Lachin, John** (2002): Randomization in Clinical Trials: Theory and Practice. John Wiley.

E07: OFFICIAL STATISTICS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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

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 2: 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 3: Economic development: Growth in per capita income and distributive justice indices of devel- opment, human development index. National income estimation- Product approach, income approach and expenditure approach.

Unit 4: 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 Verlag.
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 Measurement, New Age International.

E08: STATISTICAL ECOLOGY AND DEMOGRAPHY

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Understand the concept of population dynamics
CO2: Discuss the simpson's index and related topics.
CO3: Understand the sources of demographic data
CO4: Discuss the structure of population and various population theories

Unit-1: Population Dynamics: One species - exponential, logistic and Gompertz models. Two species competition, coexistence, predator - prey oscillation, Lotka - Volterra equations, isoclines. Leslie matrix model for age structured populations. Survivorship curves - constant hazard rate, monotone hazard rate and bath-tub shaped hazard rates. Population density estimation: Capture- recapture models, nearest neighbor models, line transect sampling.

Unit-2: Ecological Diversity: Simpson's index, Shannon - Weaver index, Diversity as average rarity. Optimal Harvesting of Natural Resources, Maximum sustainable yield, tragedy of the commons. Game theory in ecology: Concept of Evolutionarily stable strategy, its properties, simple cases such as Hawk-Dove game. Foraging Theory: Diet choice problem, patch choice problem, mean variance trade-off.

Unit-3: Demography: Sources of Demographic data: Census, Vital Registration System, Sample surveys. Population Composition and Structure- Age, Sex, Religion, Education, Income, Dependency, Population pyramid. Concepts of Fertility, Nuptiality, Mortality, Morbidity, Migration and Urbanization. Determinants and consequences of population change. Measurement of mortality and morbidity, Force of mortality. Measurement of fertility- TFR, GRR, NRR.-Life tables, uses in Demography Multiple decrement and multi-state life tables.

Unit-4: Structure of population- Lotka's stable population theory, Stationery and quasi-stable popula- tion, population momentum, population waves. Population growth- exponential, logistic- population esti- mation and projection- Mathematical and component methods. Stochastic models for population changes- birth and death process- migration models- model life tables- U.N., Coale & Demeny, Leaderman's system, Brass' Logit system, U.N. tables for developing countries- Stable population models.

Text Books / References

1. **Gore A.P. and Paranjpe S.A**.(2000): A Course on Mathematical and Statistical Ecology, Kluwer Aca- demic Publishers.
2. **Pielou, E.C.(**1977): An Introduction to Mathematical Ecology, Wiley.
3. **Seber, G.A.F**.(1982): The estimation of animal abundance and related parameters 2nd Ed., C.Griffin.
4. **Clark, C.W.(**1976): Mathematical bio-economics : the optimal management of renewable resources (Wiley)
5. **Maynard Smith J**. (1982): Evolution and the theory of games, Cambridge University Press.
6. **Stephens D.W. & Krebs, J. R**. (1986): Foraging Theory, Princeton University Press.

7. **Henry, S. Shryock and Jacob, S. Siegel** (1976): Methods and Materials of Demography, Academic Press, New York.
8. **Ramkumar, R. and Gopal, Y. S.** (1996): Technical Demography, Wiley Eastern Limited.
9. **Srinivasan, K.(**1998):. Basic Demographic Techniques and Applications; Sage Publications, New Delhi.
10. **Asha, A. Bhende and Tara Kanitkar** : Population Studies (5th revised edition), Himalaya Publishing House, New Delhi.
11. **Krishnan Namboodiri and C. M. Suchindran** (1987): Life table techniques and their applications, Academic Press, London.
12. **Saxena, P. C. and Talwar, P. P**. (1987): Recent Advances in the Techniques for Demographic Analysis, Himalaya Publishing House.
13. UNDP (2003): Human Development Report.
14. **Bartholomew, D. J.** (1982): Stochastic Models for Social Processes, John Wiley.
15. **Keyfitz, N.** (1977): Applied Mathematical Demography; Springer Verlag.

E09: LONGITUDINAL DATA ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: Understand the concept of longitudinal data
CO2: Discuss the generalized linear models.
CO3: Understand the concept of classification
CO4: Discuss the structure of multivariate longitudinal data

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-2: 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-3: 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-4: 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.

Text Books

1. **Diggle, P.J., Heagerty, P., Liang, K.Y and Zeger. S.L** (2003). Analysis of Longitudinal Data, 2nd Edn. 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.
4. **Lindsey, J.K.** (1993) Models for Repeated Measurements. Oxford University Press, New York.
5. **Little, R.J.A, and Rubin, O.B.** (2002) Statistical Analysis with Missing Data, 2nd edition, Wiley, New York.
6. **McCullagh,P. and Nelder.J.A** (1989) Generalized Linear Models. 2nd edition, Chapman and Hall/CRC Press, London.
7. **Weiss, R.E.** (2005) Modeling Longitudinal Data. Springer, New York.

E10: GENERALIZED LINEAR MODELS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1: To study various aspects of multivariate normal density.

CO2: To derive maximum likelihood estimates of various parameters and their sampling distributions.

CO3: To create various test procedures and their implementation.

CO4: Introduce and analyze some special techniques such as principle component analysis, factor analysis and canonical correlation.

Unit-1: Exponential family of distributions and properties (Normal, Binomial and Poisson) Review of models for normal response models Tables, measures of association and odds ratios. Generalized linear models- Three part specification, examples.

Unit-2: Logistic and Poisson regression: logit model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance, variable selection, introduction to Poisson regression, MLE for Poisson regression, Applications in Poisson regressions, Lack of fit in Logistic regression.

Unit-3: Log linear models for contingency tables: interpretation of parameters, ML estimation of pa- rameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, partial association.

Unit-4: Family of Generalized Linear Models: Exponential family of distributions, Formal structure for the class of GLMs, Likelihood equations, Quasi likelihood, Link functions, Important distributions for GLMs, Power class link function.

References:

1. **Agresti**,(2007) A. An Introduction to Categorical Data Analysis, Second Edition. Wiley, .
2. **Agresti,** (2002)A. Categorical Data Analysis, Second Edition. Wiley.
3. **Dobson, A. J.** An Introduction to Generalized Linear Models, Second Edition. Chapman & Hall, 2001.
4. **Christensen, R.** (1997). Log-linear Models and Logistic Regression, Second Edition. Springer.
5. **Green, P.J. and Silverman, B.W**. (1994). Nonparametric Regression and Generalized Linear Models. Chapman and Hall, New York.
6. **Hasting, T.J. and Tibshirani, R.J.** (1999), Generalized Additive Models. Second Edition, Chapman and Hall, New York.
7. **Hosmer, D.W. and Lemeshow, S.** (2000). Applied Logistic Regression, Second Edition. Wiley, New York.
8. **McCullagh, P. and Nelder, J.A.** (1999). Generalized Linear Models, Second Edition. Chapman and Hall.
9. **McCulloch, C.E. and Searle, S.R.** (2001). Generalized Linear and Mixed Models. John Wiley & Sons, Inc. New York.
10. **Myers, R.H., Montgomery, D.C and Vining, G.G.** (2002). Generalized Linear Models With Applications in Engineering and the Sciences. John Wiley & Sons.

E11: TIME SERIES ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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;

Unit-1: 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 on smoothing, Adaptive smoothing.

Unit-2: Detailed study of the stationary process: Autoregressive, Moving Average, Autoregressive Moving Average and Autoregressive Integrated Moving Average Models. Choice of AR / MA periods.

Unit-3: 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 R.

Unit-4: Spectral analysis of weakly stationary process. Herglotzic Theorem. Periodogram and correlo- gram analysis. Introduction to non-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.
2. **Brockwell P.J.and Davis R.A.** (1987). Time Series: Theory and Methods, Springer - Verlag.
3. **Abraham B and Ledolter J.C.** (1983). Statistical Methods for Forecasting, Wiely
4. **Ruey S Tsay** (2005), Analysis of financial time series second edition, john Wiley and sons

References

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

E12: COMPUTER ORIENTED STATISTICAL METHODS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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

Unit-1: 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-2: R-Graphics- Histogram, Box-plot, Stem and leaf plot, Scatter plot, Matplot, Plot options; Multi- ple plots in a single graphic window, Adjusting graphical parameters. Looping- For loop, repeat loop, while loop, if command, if else command.

Unit-3: Bootstrap methods: re-sampling paradigms, bias and standard errors, Bootstrapping for esti- mation 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 heterosedasticity cross-validation for tuning parameters.

Unit-4: EM algorithm: applications to missing and incomplete data problems, mixture models. Appli- cations 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, ISBN:978-0-387-93836-3.
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).

E13: STATISTICAL DECISION THEORY AND BAYESIAN ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

CO1:To understand clearly the relevance of various aspects of decision theory such as loss function, prior information and different principles of decision theory.

CO2: To study how utility function can be constructed in real life situations and transform it into a loss function.

CO3: To study the relevance of various loss function such as squared error loss function, zero-one loss function and linear loss function.

CO4: To study the logic of Bayesian decision theory, its analysis and significance.

Unit-1: Statistical decision Problem - Decision rule and loss, randomized decision rule. Decision Principles sufficient statistic and convexity. Utility and loss-loss functions, standard loss functions

Unit-2: Prior information-subjective determination of prior density-Non-informative priors maximum entropy priors, location and scale invariant priors, Jeffrey's prior, the ML-II approach to prior selection. Conjugate priors, Baye's estimation, game theory, minimax theorem(without proof), statistical games, method of finding minimax estimation, credible intervals

Unit-3: Baye's hypothesis testing, prior and posterior odds, Baye's factor, Lindley's procedure for test of significance, decision theoretic approach to testing problem, predictive inference-introduction, standard predictive distribution, Laplace rule of succession , prediction for exponential family of distribution, Baye's prediction with induced loss.

Unit-4: Bayesian inference for the linear model, homoscedastic disturbances, heteroscedastic disturbances, predictive distribution, estimation, hypothesis testing, general linear model, empirical Bayes model, robustness

Text Books

1. **Berger, O,J.(**1985). Statistical decision Theory and Bayesian Analysis, Second Edition Springer-Verlag.
2. **Ferguson, T.S.** (1967), Mathematical Statistics; A Decision-Theoretic Approach, Academic Press, New- York.
3. **Ashok K Bansal** (2007) , Bayesian parametric inference, Narosa publishing house.

E14:RELIABILITY MODELING

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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;

Unit-1: 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-2: 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-3: 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-4: Maintenance and replacement policies; availability of repairable systems; modeling of a re- pairable 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.

Text Books / References

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

E15: LIFETIME DATA ANALYSIS

Lecture Hours Per Week:5 Credits:4

Course Outcomes

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;

Unit-1: 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-2: The product-limit estimator and its properties. The Nelson-Aalen estimator, 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-3: 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, infer- ence for log-location scale distribution: likelihood based methods: Exact methods under type-2 censoring; application to Weibull and extreme value distributions, comparison of distributions.

Unit-4: 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 Wilcox on 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 Inc., New Jersey.
2. **Kalbfiesche, J.D. and Prentice, R.L.** (1980): The statistical Analysis of Failure Time Data, John Wiley & Sons Inc. New Jersey.

References

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