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

UNIVERSITY OF CALICUT

Abstract

Master of Science (M.Sc)programme in Statistics (offered by SDE)- Rules, Regulations and Syllabus- Approved-Implemented-w.e.f 2015 Admissions-Orders issued

G & A - IV - J

U.O.No. 11186/2015/Admn Dated, Calicut University.P.O, 30.10.2015

Read:-1. Item No. 3 in the minutes of the meeting of the Board of Studies in Statistics PG held on 18.08.2015

2. Approval of Dean, Faculty of Science dated 13.10.2015

3. Approval of Vice Chancellor dated 16.10.2015

4. Orders in the file of even No.

ORDER

Vide paper read as first above, the Board of Studies in Statistics PG finalised the Rules, Regulations and Syllabus of M.Sc Programme in Statistics (offered by SDE) prepared as per the decisions of its previous meetings and submitted the syllabus.

The Dean, Faculty of Science vide paper read as (2)above, approved the resolution of the Board of Studies.

The Vice Chancellor, vide paper read as (3) has approved the remarks of the Dean,approving the Rules, Regulations and Syllabus of M.Sc Programme in Statistics (offered by SDE), subject to the ratification of Academic Council.

Sanction has, therefore, been accorded to implement the Rules, Regulations and Syllabus of M.Sc Programme in Statistics (offered by SDE),subject to the ratification of Academic Council.

Orders are issued accordingly.

The syllabus is available in the University website: www.universityofcalicut.info

Usha K
Deputy Registrar

To

School of Distance Education

Copy to:

PS to VC/PA to Registrar/ PA to CE/ Board of Studies in Statistics PG

Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT

REGULATIONS OF M. Sc. STATISTICS PROGRAMME

IN SCHOOL OF DISTANCE EDUCATION UNDER CUCSS MODE

(To be implemented with effect from 2015 admission)

1. Title of the programme

This DEGREE shall be called MASTER OF SCIENCE (STATISTICS)

2. Eligibility for admission

Any student who has passed a degree with aggregate 50% marks with Mathematics/ Statistics as core subject, of University of Calicut or that of any other University or institute recognized by the UGC are eligible for admission. However, SC/ST, OBC, and other eligible communities shall be given relaxation as per University rules.

For the administration of this programme, a Coordinator shall be appointed from among the teachers of Statistics. The co-ordinator will be in-charge of the conduct of contact classes, practicals and project work of the programme.

3. Medium of Instruction and examination

The medium of instruction and examination shall be English.

4. Schedule and Hours of Lecture

The programme shall have four semesters. Each semester shall consist of 16 weeks. Instruction and University examinations in each course in a semester shall be completed within 90 days in a semester. University shall arrange contact classes/practical at notified centres on week end holidays and other public holidays.

5. Attendance

A student shall attend at least a minimum of 75 % of the number of contact classes actually conducted in a semester to be eligible for appearing for university examination of that semester. Course wise minimum attendance for the contact classes will not be insisted. If the student has shortage of attendance

in a semester, he or she shall not be allowed to appear for examination of that semester. However, the University may condone shortage up to 10 % of the maximum number of contact hours per semester. If the candidate has shortage more than this limit he/she has to compensate the shortage of attendance of that semester along with the next batch and appear for the university examination of that semester.

6. External Examination:-

The University shall conduct semester end examinations, for each of the courses in the first, second, third and fourth semesters. The duration of examination shall be three hours for both theory paper and practical examinations.

7. Practical:-

There will be practical examinations in even semesters (viz. 2^{nd} and 4^{th}). The practical examination of 2^{nd} semester will cover courses of 1^{st} and 2^{nd} semester and practical examinations of 4^{th} semester will cover courses of 3^{rd} and 4^{th} semesters. Practical's are to be done using the software R.

8. Project Work

The students shall do a project during their final semester under a faculty guide. This project work is to be done individually by the students. The student shall prepare and submit a project report, printed and submitted to the Coordinator before the last working day of the final semester. The project done during the fourth semester shall be evaluated by examiners appointed by the controller of examinations.

9. Viva Voce Examination:-

At the end of fourth semester, each student shall attend a comprehensive viva voce examination. The Viva Board shall have at least two members. The University shall appoint the examiners. The viva voce w ill be about all the courses of the four- semester programme, including project reports.

10. Programme Structure:-

Semester I (Total Credits : 20)

Course Code	**Type**	**Course Title**	**Credits**
ST1C01	Core	Measure Theory and Probability	4
ST1C02	Core	Analytical Tools for Statistics- I	**4**
ST1C03	Core	Analytical Tools for Statistics – II	**4**
ST1C04	Core	Linear Programming and its Applications	**4**
ST1C05	Core	Distribution Theory	**4**
		TOTAL	**20 credits**

II SEMESTER (Total Credits: **18**)

Course Code	**Type**	**Course Title**	**Credits**
ST2C06	Core	Estimation Theory	4
ST2C07	Core	Sampling Theory	**4**
ST2C08	Core	Regression Methods	**4**
ST2C09	Core	Design and Analysis of Experiments	**4**
ST2C10	Core	Statistical Computing– I (Practical course)	**2**
		TOTAL	**18 credits**

III SEMESTER (Total Credits: **16**)

Course Code	**Type**	**Course Title**	**Credits**
ST3C11	Core	Stochastic Processes	4
ST3C12	Core	Testing of Statistical Hypotheses	**4**
ST3E.....	Elective	Elective-I	**4**
ST3E.....	Elective	Elective-II	**4**
		TOTAL	**16 credits**

IV SEMESTER (Total Credits: **18**)

Course Code	**Type**	**Course Title**	**Credits**
ST4C13	Core	Multivariate Analysis	4
ST4E.....	Elective	Elective-III	**4**
ST4C14		Project/Dissertation and External Viva-Voce	**8**
ST4C15	Core	Statistical Computing– II (Practical course)	**2**
		TOTAL	**18 credits**

Total Credits: **72** (Core courses-**52**, Elective courses-**12** and Project / Dissertation -**8**)

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

Course code .	**Course Title**	**Credits**
E01	Advanced Operations Research	4
E02	Biostatistics	4
E03	Econometric Models	4
E04	Statistical Quality Control	4
E05	Reliability Modeling	4
E06	Advanced Probability	4
E07	Time Series Analysis	4
E08	Computer Oriented Statistical Methods	4

E09	Lifetime Data Analysis	4
E10	Statistical Decision Theory and Bayesian Analysis	4
E11	Statistical Ecology and Demography	4

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 **twelve short answer questions**, each of **weightage 1**, in which **all questions** are to be answered; **Part-B** with **twelve short answer type questions** each of **weightage 2**, in which **any eight questions** are to be answered and **Part-C** consisting of **four essay type questions** each of **weightage 4** in which **any two questions** are to be answered. The questions are to be evenly distributed over the entire syllabus within each part.

11. DETAILED SYLLABI OF COURSES OFFERED IN SEMESTER -I

ST1C01: Measure Theory and Probability (4 Credits)

Unit- 1 . Sets, Classes of sets, Measure space, Measurable functions and Distribution functions : Sets and sequence of sets, set operations, limit supremum, limit infimum and limit of sets, Indicator function, fields ,sigma fields, monotonic class, Borel field on the real line, set functions, Measure, measure space, probability space, examples of measures, properties of measures, measurable functions, random variables and measurable transformations, induced measure and distribution function, Jordan decomposition theorem for distribution ,multivariate distribution function, continuity theorem for additive set functions and applications, almost everywhere convergence, convergence in measure, convergence in probabil ity, convergence almost surely, convergence in distribution.

Unit-2. Integration theory , expectation, types of convergence and limit theorems : Definition of integrals and properties, convergence theorems for integrals and expectations -Fatou's lemma, Lebesgue monotonic convergence theorem, Dominated

convergence theorem, Slutsky's theorem, convergence in (convergence in mean), inter relations between different types of convergence and counter examples.

Unit-3. Independence and Law of Large numbers:
Definition of independence, Borel Cantelli lemma, Borel zero one law, Kolmogrov 's zero one law, Weak law of large numbers(WLLN), Convergence of sums of independent random variables - Kolmogrov convergence theorem, Kolmogorov's three-series theorem. Kolmogorov's inequalities, Strong law of large numbers (SLLN), Kolmogorov's Strong law of large numbers for independent random variables, Kolmogorov's strong law large numbers for iid random variables.

Unit-4. Characteristic Function and Central limit Theorem: Characteristic function, Moments and applications, Inversion theorem and its applications, Continuity theorem for Characteristic function (statement only),Test for characteristic functions, Polya's theorem(statement only), Bochner's theorem(statement only). Cenral limit theorem for i.i.d random variables, Liapounov's Central limit theorem, Lindeberg–Feller Central limit theorem(statement only).

Text Books

1. **A.K. Basu**.(1999). Measure theory and probability. Prentice Hall of India private limited
New Delhi.

References

1. **A.K.Sen**.(1990), Measure and Probability .Narosa.
2. **Laha and Rohatgi** (1979).Probability Theory. John Wiley New York.
3. **B.R.Bhat** (1999),Modern Probability theory .Wiley Eastern ,New Delhi.
4. **Patrick Billingsly** (1991),Probability and Measure ,Second edition ,John Wiley .

ST1C02: Analytical Tools for Statistics – I (4 Credits)

Unit-1 .Multidimensional Calculus Limit and continuity of a multivariable function, derivatives of a multivariable function, Taylor 's theorem for a multivariable function.

Inverse and implicit function theorem, Optima of a multivariable function, Method of Lagrangian multipliers, Riemann integral of a multivariable function.

Unit-2. Analytical functions and complex integration:- Analytical function, harmonic function, necessary condition for a function to be analytic, sufficient condition for function to be analytic, polar form of Cauchy - Riemann equation, construction of analytical function. Complex line integral, Cauchy's theorem, Cauchy's integral formu la and its generalized form. Poisson integral formula, Morera's theorem. Cauchy's in equality, Lioville's theorem, Taylor's theorem, Laurent's theorem.

Unit-3. Singularities and Calculus of Residues.:- Zeroes of a function, singular point, different types of singularities. residue at a pole, residue at infinity, Cauchy's residue theorem, Jordan's lemma, integration around a unit circle, poles lie on the real axis, integration involving many valued function.

Unit- 4. Laplace transform and Fourier Transform

Laplace transform, Inverse Laplace transform. Applications to differential equations, The infinite Fourier transform, Fourier integral theorem. Different forms of Fourier integral formula, Fourier series.

Book for study

1. **Andre's I. Khuri**(1993) Advanced Calculus with applications in statistics. Wiley & sons

(Chapter 7)

2. **Pandey, H.D, Goyal, J. K & Gupta K.P** (2003) Complex variables and integral transforms, Pragathi Prakashan, Meerut.

3. **Churchill Ruel.V.** (1975), Complex variables and applications .McGraw Hill.

References

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

ST1C03: Analytical Tools for Statistics – II (4 Credits)

Unit-1.. Riemann-Stieltjes integral and uniform convergences .

Definition, existence and properties of Riemann -Stieltjes integral, integration by parts, change of variable, mean value theorems, sequence and series of functions, point wise and uniform convergences, test of uniform convergence, consequence of uniform c onvergence on continuity and integrability, Weirstrass theorem.

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 projections, Inverse of a parti tioned matrix, Rank of real and complex matrix, Elementary operations and reduced forms.

Unit- 3 Eigen values, spectral representation and singular value decomposition

Characteristic roots, 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, computation 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 diagonalisation 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 .

3. **Walter Rudin** (1976).Principles of Mathematical Analysis, third edition, McGraw –hill international book company New Delhi.

References

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.

ST1C04: Linear Programming and Its Applications (4 Credits)

Unit-1. Some basic algebraic concepts.

Definition of a vector space, subspaces, linear dependence and independence, basis and dimensions, direct sum and complement of subspaces, quotient space, inner product and orthogonality. Convex sets and hyperplanes.

Unit-2. Algebra of linear programming problems .

Introduction to linear programming problem(LPP), graphical solution, feasible, basic feasible and optimal basic feasible solution to an LPP, analytical results in general LPP, theoretical development of simplex method. Initial basic feasible s olution, artificial variables, big-M method, two phase simplex method, unbounded solution, LPP with unrestricted variables, degeneracy and cycling, revised simplex method.

Unit- 3. Duality theory and its applications.

Dual of an LPP, duality theorems complementary slackness theorem, economic interpretation of duality, dual simplex method. Sensitivity analysis and parametric programming, integer programming, Gomery's cutting plane algorithm and branch and bound techniques.

Unit- 4. Transportation problem and game theory.

Transportation problem, different method s of finding initial basic feasible solution , transportation algorithm, unbalanced transportation problem, assignment problem, travelling salesman problem. Game theory, pure and mixed strategies. Conversion of two person's zero sum game to an Linear programming problem. Fundamental theorem of game. Solution to game through algebraic, graphical and Linear programming method.

Text Books

1. **Ramachandra Rao and Bhimashankaran** (1992).Linear Algebra Tata McGraw hill.
2. **Cooper and Steinberg** (1975). Methods and Applications of Linear Programming, W.B. Sounders Company, Philodelphia, London.

References

1. **J.K.Sharma**(2001).Operations Research Theory and Applications.McMillan New Delhi.

2. **Hadley,G.**(1964).Linear Programming,Oxford &IBH Publishing Company,New Delhi.
3. **Kanti Swaroop,P.K. Gupta** et.al**,(**1985),Operation Research,Sultan Chand & Sons.
4. **Taha.H.A**.(1982).Operation Research and Introduction ,MacMillan.

ST1C05: Distribution Theory (4 Credits)

Unit- 1. Discrete distributions

Random variables ,Moments and Moment generating functions, Probability 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, hierarc hical 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 . Fdistributions- properties and applications. Noncentral Chi-square, t, and F-distributions.

Text Books

1. **Rohatgi, V.K.**(1976).Introduction to probability theory and mathematical statistics. John Wiley and sons.
2. **George Casella and Roger L. Berger** (2003). Statistical Inference. Wodsworth & brooks Pacefic Grove, California.

References

1. **Johnson ,N.L.,Kotz.S. and Balakrishna n, 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).Univarite Discrete distributions, John Wiley and Sons, New York.

SYLLABI OF COURSES OFFERED IN SEMESTER -II

ST2C06: Estimation Theory (4 Credits)

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 Books

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.

References

1. **Lehmann, E.L** (1983). Theory of point estimation, John Wiley and sons, New York.

2. **Rohatgi, V.K** (1976). An introduction to Probability Theory and Mathematical Statistics, John Wiley and sons, New York.

3. **Rohatgi, V.K** (1984). Statistical Inference, John Wiley and sons, New York.

4. **Rao, C.R** (2002). Linear Statistical Infe rence and its applications, Second Edition, John Wiley and sons, New York.

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ST2C07: Sampling Theory (4 credits)

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 sample 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 m ethod of estimationestimation 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 s imple mean per unit method. Ratio and regressionmethod 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 variance and its estimators, Zen -Midzuno scheme of sampling, πPS 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 / References

1. **Cochran W.G** (1992): Sampling Techniques, Wiley Eastern, New York.

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

3. **P.V.Sukhatme** et.al. (1984): Sampling Theory of Surveys with Applications. IOWA State University Press, USA.

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ST2C08: Regression Methods (4 Credits)

Unit-1: Simple and multiple regression.

Introduction to regression. Simple linear regression - least square estimation of parameters,

Hypothesis testing on slope and intercept, Interval estimation, Prediction of new observations, Coefficient of determination, Regression through origin, Estimation by maximum likelihood, case where x is random. Multiple Linear Regression- Estimation of model parameters, Hypothesis testing in multiple linear regression, Confidence interval in multiple regression, Predict ion of new observations.

Unit- 2: Model Adequacy Checking, Transformation and weighting to correct model Inadequacies. Residual analysis, the press statistics, detection of treatment of outliers, lack of fit of the regression model. Variance -stabilizing transformations, Transformation to linearize the model, Analyticalmethods for selecting a transformation, Generalized and weighted least squares.

Unit- 3: Polynomial regression model and model building.

Polynomial models in one variable, Nonparametric regression, Polynomial models in two or more variables, orthogonal variables. Indicator variables, Regression approach t o analysis of variance. Model building problem, computational techniques for variable selection.

Unit-4: Generalized Linear Models.

Logistic regression model, Poisson regression, The generalized linear models - link function and linear predictors, parameter estimation and inference in GLM, prediction and estimation in GLM, residual analysis in GLM over dispersion.

Text Books

1. **Montgomery ,D.C., Peck, E.A., Vining G Geofferey** (2003). Introduction to Linear Regression Analysis. John Wiley & Sons.

References

1. **Chatterjee, S & B. Price (1977)** . Regression analysis by example, Wiley, New York.

2. **Draper, N.R & H. Smith (1988).** Applied Regression Analysis. 3 rd Edition, Wiley, New

York.

3. **Seber, G.A.F (1977).** Linear Regression Analysis. Wiley, New York.

4. **Searle , S.R (1971).** Linear Model. Wiley, New York.

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ST2C09: Design and Analysis of Experiments (4 credits)

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 Facto r-ANOVA, Analysis of Fixed Effects Model, Model Adequacy Checking, Choice of Sample Size, ANOVA Regression Approach, Non parametric method in analysis of variance.

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 Factorial Design, 2k Factorial Design-Confounding and Partial Confounding, 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. 5 th edition, John Wiley & Sons- New York.

References

1) **Das M.N. & Giri N.S.** (2002): Design and Analysis of Experiments. 2 th edition , New Age International (P) Ltd., New Delhi.

2) **Angola Dean & Daniel Voss** (1999): Design and Analysis of Experiments. Springer - Verlag, New York.

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ST2C10: Statistical Computing-I (2 credits)

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. ST1C05: Distribution Theory 2. ST2C06: Estimation Theory 3. ST2C07: Sampling Theory 4. ST2C08: Regression Methods 5. ST2C09: 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 packages –

SPSS and SAS.

The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The external examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at t he centre will be set by the external examiner in consultation with the Chairman, BoE and the H/Ds of the centre. 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.

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SYLLABI OF COURSES OFFERED IN SEMESTER -III

ST3C11: Stochastic Processes (4 Credits)

Unit-I. Concept of Stochastic processes, examples , Specifications; Markov chains- Chapman Kolmogorov equations – classification of states – limiting probabilities; Gamblers ruin problem and Random Walk – Mean time spent in transient states – Branching processes (discrete time), Hidden Markov chains.

Unit-II. Exponential distribution – counting process – inter arrival time and waiting time distributions. Properties of Poisson proces ses – 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. Ixth 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.

ST3C12: Testing of Statistical Hypotheses (4 Credits)

Unit-I. Tests of hypotheses & 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 – Generalized Neyman–Pearson Lemma, One-sided UMP tests, two-sided UMP tests and UMP unbiased tests.

Unit-II. 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-III. 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 chisquare test for homogeneity – Kolmogorov – Smirnov test; the median test – Mann-Whitney- Wilcoxon test - Test for independence – Kendall's tau – Spearman's rank correlation coefficie nt – robustness.

Unit-IV. 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.** (1976): An Introduction to Probability Theory and Mathematical Statistics, John – Wiley Sons, New – York.

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.** (1986): Testing of Statistical Hypotheses. John Wiley, New York.

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.

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SYLLABI OF COURSES OFFERED IN SEMESTER -IV

ST4C13: Multivariate Analysis (4 Credits)

Unit-I. 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 multiv ariate 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 d istribution 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-III. Testing Problems – Mahalanobis D2 and Hotelling's T2 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; 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, 3 rd 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.

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ST4E--: …….. (Elective-III) **(4 Credits)**

(to be selected from the approved list of Electives)

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ST4C14: Project/Dissertation and External Viva -Voce (8 credits)

(**5 credits for Project/Dissertation and 3 credits for External Viva -Voce**)

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 depart ment. 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 dea dline suggested in the Academic calendar. The project/ dissertation is of **5 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, under direct grading system. The following break up of weightage is suggested for its valuation.

1 Review of literature, formulation of the problem and defining clearly the ob jective: 20%

2 Methodology and description of the techniques used: 2 0%

3 Analysis, programming/simulation and discussion of results: 2 0%

4 Presentation of the report, organization, linguistic style, reference etc.: 2 0%

5 Viva-voce examination based on project/dissertation: 20%.

The External Viva-Voce shall be conducted a Board of Examiners, consisting of at least two external experts, appointed by the University. The external viva -voce shall cover all the courses undergone in the two-year programme and carries **3 credits**. The evaluation shall be done by the direct grading system.

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ST4C15: Statistical Computing-II (2 credits)

(Practical Course)

Teaching scheme: **6** hours practical per week.

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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 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 t he time of external examination. Students are expected to acquire working knowledge of the statistical packages – SPSS and SAS. The Board of Examiners (BoE) shall decide the pattern of question paper and the duration of the external examination. The extern al examination at each centre shall be conducted and evaluated on the same day jointly by two examiners – one external and one internal, appointed at the centre of the examination by the University on the recommendation of the Chairman, BoE. The question paper for the external examination at the centre will be set by the external examiner in consultation with the Chairman, BoE and the H/Ds of the centre. The questions are to be evenly distributed over the entire syllabus. Evaluation shall be done by assess ing 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.

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

Sl. No. Course Title Credits

E01 Advanced Operations Research 4

E02 Biostatistics 4

E03 Econometric Models 4

E04 Statistical Quality Control 4

E05 Reliability Modeling 4

E06 Advanced Probability 4

E07 Time Series Analysis 4

E08 Computer Oriented Statistical Methods 4

E09 Lifetime Data Analysis 4

E10 Statistical Decision Theory and Bayesian Analysis 4

E11 Statistical Ecology and Demography 4

SYLLABI OF ELECTIVE COURSES

E01: Advanced Operations Research (4 Credits)

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, co mputational economy in DP. Concept andexamples of Geometric programming.

Unit-III. Project management: CPM and PERT; probability of project completion; PERT - crashing. 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 newspaper boy 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, conv olution method, acceptance-rejection methods, generation of random numbers , Mechanics of discrete simulation.

Text Books

1. **K.V.Mital and Mohan, C** (1996) – Optimization Methods in Operations Research and Systems Analysis, 3rd Edition, New Age International (Pvt.) Ltd.

2. **M.Sasieni, A.Yaspan and L.Friendman** (1959). Operations Research; Methods and Problems, Wiley, New York.

3. **Hamdy A. Taha** (1997). Operations Research – An Introduction, Prentice-Hall Inc., New Jersey.

4. **Ravindran, Philips and Solberg** (1987). Operations Research- Principles and Practice, John Wiley & Sons, New York.

References

1. **Sharma, J.K.** (2003) : Operations Research, Theory & Applications, Macmillan India Ltd.

2. **Manmohan, Kantiswaroop and Gupta** (1999). Operation Research, Sultan Chand & Sons New Delhi.

3. **Hadley G. and Whitin, T.M.** (1963): Analysis of Inventory Systems; Prentice Hall.
4. **Kambo, N.S.** (1984): Mathematical programming, East West Press, New Delhi.

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E02: Biostatistics(4 Credits)

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. Tests of goodness of fit for survival distributions (WE test for exponential distribution, W-test for lognormal distribution, Chi –square test for uncensored observations). Parametr ic 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, Mende l'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 trial s. 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; ethics behind

randomized studies involving human subjects; randomized dose -response studies.

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.

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E03: Econometric Models (4 Credits)

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 econome trics, 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 partia l 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 a nd 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. **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.

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E04: Statistical Quality Control (4 Credits)

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 plan s 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 the number of non - conformities. Mean charts. Median charts. Extreme value charts, R -charts, and S-charts ARI, Economic design of control charts.

Unit-IV. Basic concepts of process monitoring a nd control; process capability and process optimization. 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. 4 th edition. Wiley, New-York.

2. **Mittage, H.J. and Rinne, H.** (1993).Statistical Methods for Quality Assurance. Chapman and Hall. Chapters13 and 14.

3. **Oakland, J.S. and Follorwel, R.F.** (1990). Statistical Process Control. East -West Press. Chapters 13 and 14.

4. **Schilling, E.G.** (1982).Acceptance Sampling in Quality Control. Marcel Dekker.

5. **Duncan, A.J.** (1986). Quality Control and Industrial Statistics.

References

1. **Gerant, E.L. and Leaven Worth, R.S.** (1980). Statistical Quality Control. Mc -Graw Hill

2. **Chin-Knei Chao** (1987). Quality Programming, John Wiley.

3. **Ott, E.R.** (1975): Process Quality Control; McGraw Hill .

4. **Wetherill, G.B. and Brown, D.W** ( ).: Statistical Process Control: Theory and Practice.

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E05: Reliability Modeling (4 Credits)

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 dis tributions 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; availabil ity 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.

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 Lif etime (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,

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E06: Advanced Probability (4 Credits)

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

Unit-II. 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-III. Infinite Divisibility of Probability Distributions: Infini tely 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-IV. Conditional expectations (gene ral case) – definition and properties, Random-Nikodyn theorem, Martingales, super/sub-martingales, Doob's decomposition, stopping times, Martingale limit theorems, Introduction 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, Birkhäuser, Boston.

3. **Steutel, F.W**. and **van Harn, K**. (2004). Infinite Divisibility of Probability Distrib utions on the Real Line. Marcel Dekker Inc., New York.

References

1. **Ash R. B** (2000): Probability and Measure Theory, 2 nd edition. Academic Press.

2. **Billingsley P** (1985): Probability and Measure, 2 nd 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.

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E07: Time Series Analysis (4 Credits)

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 on 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 n-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

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.

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E08: Computer Oriented Statistical Methods (4 Credits)

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, bootstra pping 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 inc omplete 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,
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).

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E09: Lifetime Data Analysis (4 Credits)

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 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-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 and extreme 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 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. Chapman and Hall.

5. **Lee, Elisa, T**. (1992): Statistical Methods for Survival D ata Analysis, John Wiley & Sons.

E10: Statistical Decision Theory and Bayesian Analysis (4 Credits)

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 priorsmaximum entropy priors , the marginal distribution to determine the prior-the ML-II approach to prior selection. Conjugate priors.

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

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

Text Book

1. **Berger, O,J.**(1985). Statistical decision Theory and Bayesian Analysis, Second Edition Springer-Verlag.

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.

3. **Giovanni Parmigiani, Luroles, Y.T. Inouve** and **Hedibert F. Lopes** (2009): Decision Theory- Principles and Approaches, John Wiley.

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E11: Statistical Ecology and Demography (4 Credits)

Unit-I. 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-II. 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, it s properties, simple cases such as Hawk-Dove game. Foraging Theory: Diet choice problem, patch choice problem, mean variance trade-off.

Unit-III. 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-IV. Structure of population- Lotka's stable population theory, Stationery and quasi -stable population, population momentum, population waves. Population growth - exponential, logistic- population estimation 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 Academic 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 2 nd 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 A pplications; 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.

Sd/-

(Dr Jenson P O)

Chairman,PG BoS(Statistics)