File Ref.No.5106/GA - IV - J2/2012/CU

UNIVERSITY OF CALICUT

Abstract

M.Phil programme in Statistics-Revised Syllabus-approved-implemented with effect from 2013 admissions-Orders issued.

UNIVERSITY OF CALICUT (G & A - IV - J)

U.O.No. 4967/2013/CU Dated, Calicut University.P.O, 22.10.2013

Read:-1.U.O.No.GA IV/J2/4230/10 dated 26.07.2010.

2.Item no. 5 (iii) of the minutes of the Board of Studies in Statistics PG held on 18.03.2013.

3.Item no. 2 of the minutes of the Faculty of Science held on 22.03.2013.

4.Item no. II C (page 59) of the minutes of the Academic Council held on 30.07.2013.

5.Orders of the Registrar.

ORDER

The Syllabus of MPhil programme in Statisitics with effect from 2010 admissions was implemented vide paper read as (1).

The Board of Studies in Satistics PG, vide paper read as (2), resolved to approve the Revised Syllabus of M.Phil programme in Statistics, with effect from 2013 admissions.

The Faculty of Science and the Academic Council also have approved the same vide paper read as (4) and (5) respectively.

Sanction has, therefore, been accorded for implementing the Revised Syllabus of M.Phil programme in Statistics , under the University with effect from 2013 admissions.

Orders are issued accordingly.

(The Syllabus is available in the Official website of the University:universityofcalicut.info)

Prof.Raveendranath K

Registrar

To

1.The Directorate of Research, University of Calicut

2.The College Development Council.

3.The Controller of Examinations

4.The Pareeksha Bhavan.

Forwarded / By Order

Section Officer

Master of Philosophy (M. Phil.) Degree Programme in Statistics

(Structure & Syllabi w.e.f. 2013 Admission onwards)

Duration: One year programme in two continuous semesters.
Total Credits: 24

Semester-I (Total Credits: 12)

Paper-1: Research Methodology (4 Credits)

Paper-2: Advanced Trends in Statistics (4 Credits) and

Paper-3: Specialization (4 Credits)

- E01: Longitudinal Data Analysis
- E02: Stochastic Models in Queueing Theory
- E03: Advanced Queueing Systems
- E04: Laplace Distributions
- E05: Circular Distributions
- E06: Limit Theorems and Stability of Random Sums
- E07: Classical Extreme Value Models
- E08: Stochastic Models in Reliability

Semester-II (Total Credits: 12)

Dissertation & Viva-voce (12 Credits)

MODEL QUESTION PAPER

First Semester M.Phil. Degree Examination in Statistics , Month–Year

Course no.:
Course Code & Title (_ Credits)

[Note: Answer any **Five** questions. Each question carries **16** marks.]

Time: **3** Hours Maximum Marks: **80**

1. (a) …..
   (b) …...

2. (a) …..
   (b) …...

3. (a) …..
   (b) …...

4. (a) …..
   (b) …...

5. (a) …..
   (b) …...

6. (a) …..
   (b) …...

7. (a) …..
   (b) …...

8. (a) …..
   (b) …...

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Syllabus

Paper 1: Research Methodology in Statistics (4 Credits)

This course introduces some Statistical concepts and methods which potential students will find useful in preparing for work on a research degree in Statistics. Focus is on applications of state-of –the-art. Statistical techniques and their underlying theory.

Unit. I. Concept of Research in Statistics-Importance and Need for Research Ethics, Selection of Topic for Research-Research schedules, Review of Literature and its Use in Designing a Research Work-Mode of Literature Survey-Books and Monographs, Journals, Conference Proceedings, Abstracting and Indexing Journals, E-Journals/Books and CD-ROMS-Reports etc. Thesis Writing – Computer Application in Scientific Research-www-Searching Scientific Articles-Statistical Data Base. History of Statistics. Statistical Heritage of India.

Unit. II: Scientific Word Processing with LaTeX and MS-Word: Article, Thesis Report and Slides Making-Power Point Features, Slide Preparation. Statistical Programming with R: Simple Manipulations Using Numbers and Vectors-Objects & Their Attributes-Arrays and Matrices-Lists and Data Frames-Grouping, Loops and Conditions-User Defined Functions-Probability Distributions and Statistical Models in R.

Unit. III: Simulation: Concepts and Advantages of Simulation-Event Type Simulation-Random Variable Generation-U(0,1), Exponential, Gamma and Normal Random Variables – Monte Carlo Integration. The MCMC Principle, Algorithms and its Variants, Bootstrap Methods.

Unit. IV: Computer Oriented Numerical Methods-Algorithms for Solving Algebraic and Transcendental Equations-Numerical Integration-Matrix operations.

References

1. Anderson, J., Durston, B.H., Pooole, M. (1970) Thesis and Assignment Writing. Wiley Eastern. Ltd., New Delhi.
2. Beveridege, B. (1979) The Art of Scientific Investigation. W.E. Norton & Co., New York.
3. Braun, J., Duncan, W. and Murdock, J. (2008) A First Course in Statistical

Programming with R. Cambridge University Press, London.

4. Chambers, J. (2008) Software for Data Analysis: Programming with R. Springer, New York.
5. Crewley, M.J. (2007) The R-.Book. John Wiley, New York.
6. Dalgaard, P.(2008) Introductory Statistics with R. Springer Science, New York.
7. Ghosh, J.K., Mitra, S.K. and Parthasarathy, K. R.(1992) Glilmpses of India's Statistical Heritage. Wiley Eastern Limited, New Delhi.
8. Hald, A.(1998) A History of Mathematical Statistics from 1750 to 1930. John Wiley & Sons, New York.
9. Kantiswarup, S., Gupta P.K. and Man Mohan (2008) Operations Research. Sultan Chand & Sons, New Delhi.
10. Kothari, C. (2005) Research Methodology. New Age International. Publishers,
    New York.
11. Lamport, L. (1999) LATEX: A Document Preparation System. Addison, Wesley, 2nd edition, New York
12. Pannerselvan,R. (2006) Research Methodology. Prentice-Hall of India. Pvt., NewDelhi.
13. Robert, C.P. and Casella, G. (2004) Monte Carlo Statistical Methods. Springer Science, New York.
14. Venkataraman, M.K. (1998) Numerical Methods in Science and Engineering. The National Publishing Company, Chennai.

Paper 2: Advanced trends in Statistics (4 Credits)

Unit I. Distribution Theory: Systems of Distributions –Johnson's S_B System, Johnson's S_u System, Burr Distributions. Infinite Divisibility of Probability Distributions: Infinitely Divisible Distribution on (i) The Non-Negative Integers.(ii) The Non-Negative Reals.

Unit II: U-Statistics: Basic Description of U-Statistics- The Variance and Other Moments of a U- Statistic- The Projection of a U-Statistic on the Basic Observations- Almost Sure Behavior of U-Statistics- Asymptotic Distribution Theory of U-Statistics, Non-parametric density estimation.

Unit III: Generalized Linear Models: (GLM). The Origin of GLM-An Outline of GLM-Models with Continuous Data with Constant Variance-Binary Data- Polytomous Data-Log- Linear Models-Models for Survival Data.

Unit IV: Stochastic Order Relations: Stochastically Larger, Couplings, Hazard Rate Ordering, Likelihood Ratio Ordering, Variability Ordering-Applications- Associated random variables.

References

1. Laha, R.G. and Rotatgi, V.K. (1979). Probability Theory. Wiley, New York.
2. Mc Cullagh, P. and Nelder, J.A (1983). Generalized Linear Models. Chapman and Hall Ltd., Cambridge.
3. Ross, S.M.(1996). Stochastic Processes (Chapter-9). John Wiley & Sons, New York.
4. Serfling, R.J.(1980). Approximation Theorems of Mathematical Statistics (Chapter-5). John Wiley and Sons, Canada.
5. Steutel, F.W. and van Harn, K. (2004). Infinite Divisibility of Probability Distributions on the Real Line. Marcel Dekker Inc., New York.

Paper 3: Specialization

E01: Longitudinal Data Analysis (4 Credits)

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 of Missing Data Mechanisms; 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.

References

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

Paper 3: Specialization

E02: Stochastic Models in Queuing Theory (4 Credits)

Unit I : Markovian Queuing Models: M/M/1 Queues, M/M/1/K Model., M/M/∞ Model, M/M/c Model, Transient Behavior of M/M/1 Systems, $M/E^k/1$ and $E^k/M/1$ Systems., Bulk Queues $M^x/M/1$, $M/M^{(a,b)}/1$ Models.

Unit II. Network. of Queues: Markovian Queues; Tandem queues, Jackson Network, Gordon and Newell Network, Cyclic Queue, BCMP Networks.

Unit III: Non-Markovian Queueing Systems: Embedded. Markov Chain Technique for M/G/1 model, Pollaezck-Khinchin Formula, Busy Period. Narration of M/G/1/N, M^X /G/1; $M/G^{(a,b)}/1$ Model, G/M/1 Model, Transient State Distribution of M/G/∞ Model; Markov Renewal Process and Semi-Markov Processes.

Unit IV: Vacation Models and Retrial Queues: Queuing Systems with Vacations-Stochastic Decompositions. M/G/1 Systems with Vacations. Retrial Queuing Systems - Model Description -M/M/1, M/G/1 Retrial Queues-Heavy Tailed Distributions-M/G/1 System with Heavy Tailed Service Time.

References

1. Medhi, J. (2003) Stochastic Models in Queuing theory. Second Edition, Academic Press, Elsevier Science(USA).
2. Bhat, B.R. (2000) Stochastic Models-Analysis and Application. New Age International Publishers, New Delhi.
3. Gross, D. and Harris, C.M. (1985) Fundamentals of Queuing Theory, 2nd Edn. John Wiley & Sons, New York.
4. Bose, S.K.(2002). An Introduction to Queuing systems. Kluwer Academic/ Plenum Publishers, New York.
5. Cinlar, E.(1975). Introduction to Stochastic Processes, Prentice-Hall, Englewood Cliffs, New Jersey.

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Paper 3: Specialization

E03: Advanced Queueing Systems (4 Credits)

Unit I: Basic Queueing Theory: Model Parameters-Basic Models. Kendall's Notation-Little's Result-Equilibrium Solutions for M/M/-/- Queues-Delay Analysis for M/M/1/∞/FCFS Model-Departure Process from M/M//∞ Queues -Time Reversibility Property of MCs-Queues with Bulk/Batch Arrivals.

Unit II: Performance Analysis of M/G/1 Queue in Equilibrium: The Residual Life Approach-The Imbedded MC Approach-Distributions of Time Spent in System and Waiting Time Prior to Service-Busy Period Analysis- Delay Analysis.

Unit III: Advanced Queueing Theory: M/G/1 Queue with Vacation-$M^{(x)}$/G/1 Queue-Single Server M/G/1 Priority Queues. The Discrete Time Geo/G/1 and Geo $^{(x)}$/G/1 Queues.

Unit IV. Queuing Networks and Advances: Classification of Queuing Networks-Probabilistic Routing-Open and Closed Networks. Convolution and MVA Algorithms-Norton's Theorem for Closed Queueing Networks-Mixed Queueing Networks-Approximation Techniques-Models of Blocking. Simulation Techniques for Queues and Queueing Networks: Discrete Event Simulation-Simulator Outputs for Queues-Estimation of Confidence Intervals and Levels-Transient Behavior and Warm-up Interval-Data Collection in Steady State Conditions.

References

1. Bose, S.K. (2002) An Introduction to Queuing Systems. Kluwar Academic Plenum Publishers, New York.
2. Kleinrock,L (1975) Queuing System.Vol.I, John Wiley & Sons, New York.
3. Gross, D. and Harris, C.M. (1985) Fundamentals of Queuing Theory, 2nd edn. John Wiley & Sons, New York.
4. Medhi, J. (2003) Stochastic Models in Queueing Theory. Second edition, Academic Press, Elsevier Science ,USA.

Paper 3: Specialization

E04: Laplace Distributions (4 Credits)

Unit I: Historical Background, Definition and Basic Properties- Density and Distribution Functions, Characteristic Function, Moments and Related Parameters, Entropy, Quartiles and Quantiles.

Unit II: Representations and Characterizations- Mixture of Normal, Relation to Exponential, Pareto, Stability with respect to Geometric Summation, Distributional Limits of Geometric Sums, Stability with respect to the Ordinary Summation.

Unit III: Order Statistics- Distribution of a Single Order Statistics- the Minimum, Maximum, Median, Joint Distribution of Order Statistics-Range, Mid Range, Sample Median, Point Estimation- MLE, MLE Under Censoring, MLE of Monotone Location Parameters, The Method of Moments, Linear Estimation.

Unit IV: Testing of Hypothesis- Testing Normal versus Laplace, Goodness of Fit Tests, Neyman-Pearson Test for Location, Asymptotic Optimality of KS Test, Comparison of Non-Parametric Tests for Location.

References

1. Kotz, S., Kozubowski, T.J. and Podgorski, K. (2001) The Laplace Distribution and Generalizations. Birkhauser, Boston.

2. Johnson, N. L., Kotz,S. and Balakrishnan, N. (1994) Continuous Univariate Distributions - Vol. I &II (Second Edition), Wiley, New York.

3. Lehmann, E.L. (1983) Theory of Point Estimation. Wiley, New York.

4. Rohatgi, V.K.(1984) Statistical Inference. Wiley, New York.

Paper 3: Specialization

E05: Circular Distributions (4 Credits)

Unit I: Descriptive Measures of Circular Distributions- Mean Direction, Median Direction, Mode, Circular Variance, Circular Mean Deviation, Quartile Deviation, Circular Range, Trigonometric Moments, Skewness and Kurtosis.

Unit II: Distribution Function, Characteristic Function, Fourier Steiltjes Series, Independence, Theorems on Characteristic Functions, Circular Models- Point Distribution, Uniform Distribution, Cardioid Distribution.

Unit III: Von Mises Distribution, Shape, Relation with Other Distributions, Characteristic Function and Moments, Distribution Function, Characterizations.

Unit IV: Wrapped Distributions- Definition and Properties, Wrapped Poisson, Wrapped Normal, Wrapped Cauchy, Generalized Wrapped Stable Distributions.

References

1. Jammalamadaka S. Rao and Sen Gupta, A. (2001) Topics in Circular Statistics. World Scientific, New York.

2. Mardia, K.V. (1972) Statistics of Directional Data. Academic Press, London.

3. Mardia, K. V. and Jupp, P.E. (2000) Directional Statistics. Wiley, New York.

Paper 3: Specialization

E06: Limit Theorems and Stability of Random Sums (4 Credits)

Unit I: Stable Probabilistic Schemes: Summation Stable Distributions- Strictly and Symmetric Stable Vectors, Domains of Attraction, One Dimensional Case; Max-Stable and Min-Stable Distributions, Multiplication Stable Distributions, Geometric Summation Stable Distributions, Geometric Max-Stable, Geometric Min-Stable, Geometric Multiplication Stable Distributions

Unit II: Central Pre-limit Theorems- Introduction and Motivating Examples, Central Pre-limit theorems, ¬ - Infinitely Divisible Distributions and Stable Distributions: Sums of a Random Number of Random Variables- Examples, Limit Theorems and Transfer Theorems, ¬ - Gaussian Random Variables, Examples of Summation Schemes Admitting Schemes ¬ - Strictly Gaussian Laws, ¬ - Infinitely Divisible Random Variables. Accompanying Laws.

Unit III: Approximation of Random Sums- Approximation of Geometric Sums, Random Sums of Random Vectors, Domains of Attraction of Multivariate Geometrically Stable Laws, Bounds for Random Sums, Domain of Attraction of ¬ -Stable Random Vectors, Rate of Convergence.

Unit IV: Geometric Stable Distributions on the Real Line- Preliminaries; Special Cases- Strictly GS Laws, Linnik Distributions, Symmetric Linnik Distributions, Mittag-Leffler Distributions; Stability Properties and Characterizations- Representations- Basic Representation, Alternative Representation- Linnik Distributions, Mittag-Leffler Laws, Strictly GS Laws, General Case; Densities and Distribution Functions- General GS Laws.

References

1. Kalashnikov, V. (1997) Geometric Sums: Bounds for Rare Events with Applications. Kluwer Acad.Publ., Dordrecht.

2. Klebanov, L.B., Kozubowski, T.J. and Rachev, S.T. (2006) Ill-Posed Problems in Probability and Stability of Random Sums. Nova Science Publishers, Inc., New York.

3. Gnedenko, V. and Korolev, Yu.V. (1996). Random Summation: Limit Theorems and Applications. CRC Press, Boca Raton.

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Paper 3: Specialization

E07: Classical Extreme Value Models (4 Credits)

Unit 1: Maximum, minimum and other order statistics of a sequence ofiid random variables - stability of maxima and minima, Inverse functions and Khintchine's theorem, Max-stable distributions, Extremal types theorem, Type I, Type II and Type III extreme value distributions, Generalised Extreme Value Distributions (GEVD), Convergence of $P(M_n \leq u_n)$.

Unit 2: Domain of attraction problem - domain of attraction criteria forType I, Type II and Type III extreme value distributions, Sufficient condition for the domain of attraction - examples.

Unit 3: Point process approach to extremes - basic facts about point processes - definition and examples, Point process of exceedance in the iid case. Generalised Pareto Distribution (GPD), Derivation of the asymptotic distri-bution of maxima and other order statistics using point process approach.

Unit 4: Statistical method for extremal events, Exploratory data analysis forextremes - probability and quantile plots - mean excess function - Gumbel's method of exceedances. Parametric estimation for GEVD - Maximum likeli-hood estimation, method of probability weighted moments, Fitting excesses over a threshold - fitting the GPD.

References

1. Embrechts, P., Kluppelberg, C. and Mikosch, T. (1997) Modelling Ex-tremal Events for Insurance and Finance. Springer, Berlin.

2. Leadbetter, M.R., Lindgren, G., and Rootzen, H. (1983) Extremes and Related Properties of Random Sequences and Processes. Springer-Verlag, New York.

3. Resnick, S.I. (1987) Extreme Values, Regular Variation and Point Pro-cesses, Springer, New York.

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Paper 3: Specialization

E08: Stochastic Models in Reliability (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 distributions and their properties. Reliability estimation based on failure times in variously censored life tests and in tests with replacement of failed items; stress-strength reliability and its estimation.

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

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,

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Sd/-
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