DEPARTMENT OF STATISTICS
UNIVERSITY OF DELHI
DELHI-110007

REVISED M. PHIL. COURSE IN STATISTICS W.E.F. AUGUST 1999.

1. **Objectives:**

To provide course of study to postgraduates in Statistics with a view to strengthen their foundations for under taking Ph. D. work in both theoretical and Applied Statistics.

2. **Course Structure**

The M. Phil. Course will consist of two parts:

(i) M. Phil. Part I

(ii) M. Phil. Part II

(1) **M.Phil. Part I:** The M. Phil. Committee of the Department will assign three Courses to each candidate on the basis of the preferences indicated by the Candidate out of the Following courses subject to the condition that, as far as possible, at most 5 candidates will be allowed to offer any course:-

(a) Stochastic Processes

(b) Applied Probability Models

(c) Design of Experiments

(d) Design and Inference in Survey Sampling

(e) Bayesian Inference

(f) Order Statistics

(g) Bio-Statistics

(h) Multivariate Analysis

(i) Non-Parametric Methods

(j) Reliability and Life Testing

(ii) **M. Phil Part II:** Every M. Phil. student will write a dissertation on a topic pertaining to one of the three courses assigned by the M. Phil. Committee subject to the condition that, as far as possible, at most two candidates will be allowed under any supervisor. In assigning the topic for dissertation, the M. Phil. Committee will be guided by the preferences of the candidate coupled with his/ her performance in M. Phil. part I Examination.

3. **Duration of the M. Phil. Course:**

The duration of the M. Phil. Course will be one year from August 1 of the year of the commencement to July 31 of the following year and it will be a full time course.

M. Phil. Part I: August 1 to January 31 of the following year.

M. Phil. Part II: February 1 to July 31.

M. Phil Part I will be devoted to the teaching of Courses and M. Phil. Part II will be devoted to the writing of dissertation.

4. **Seats:**

Number of candidates to be admitted to the course will be restricted to 10.

5. **Eligibility for admission:**

Good academic record with first or High Second Class Master Degree in Statistics of the University of Delhi or in Examinations recognized as equivalent thereto.

6. **Content Periods:**

With a view to encourage self study by the students themselves two contact periods per week will be assigned to each course.

7. **Attendance:**

A student admitted to the M. Phil. course shall be required to attend not less than 2/3rds of the number of contact periods assigned in M. Phil. Part I.

8. **Scheme of Examination Evaluation**

A student admitted to M. Phil. course will be evaluated on the basis of

(a) Written examination in **three** courses offered by him/her in M. Phil. Part I and INTERNAL ASSESSMENT.

(b) Dissertation and viva-voce. The weightage (in terms of Marks) shall be as follows:

(a)	**Courses**	**Written**	**Internal Assessment**	**Total**
	Course I	75	25	100
	Course I	75	25	100
	Course III	75	25	100
(b) **Dissertation**				
(i) Written				150
(ii) Viva-Voce				50
			Grand Total:	500

The written examination will be held at the end of the period stipulated for M. Phil. Part I.

9. *** Internal Assessment:**

The students will be assessed on the basis of their assignments and Seminars in each course.

COURSES OF STUDY

(a) **Stochastic Processes:**

Random Walk, one-dimensional, two-dimensional, three-dimensional random walk Poisson Process, Non-homogeneous Poisson Processes, Markov chains, Markov Process, with discrete states in continuous time, Markov Processes in continuous time with continuous state space, Non Markovian Processes, Diffusion Processes. Diffusion limit of random walk. Diffusion limit of discrete branching process. General Theory. Application to population growth Queueing Processes. Epidemic Processes. Simple epidemics, General epidemics. Competition Predation. Competition between two species. A prey-predate model.

Applications in ecology, biology, Operational Research, Physics, Chemistry and Sociology.

Suggested Readings:

1. N.T.J. Bailey: The. Elements of Stochastic Processes.
2. M. S. Bartlett: Introduction to Stochastic Processes, Cambridge.
3. A.T. Bharucha Reid: Elements of the Theory of Markov Processes and their Applications, MC-Graw Hill.
4. D.R. Cox and H.D. Miller: The Theory of Stochastic Processes, Mathuen.
5. Emanuel Parzen; Stochastic Processes.
6 Sheldon M. Ross: Stochastic Processes.
7. L.Takacs: Stochastic Processes, Mathuen.

(b) **Applied Probability Models**

Discrete Probability distributions: Families of discrete distribution-Lattice Distributions, Power series distributions, difference equation system, Kemp families Distributions based on Lagrangian expansions. Distributions via Urn models, Urn model with predetermined strategy. Generalised distribution; Mixture distribution, Cluster distributions of order k.

Queueing Models: Cox distribution, Transient solutions of queueing systems- Lattice path approach.

Suggested Readings:

1. W.M. Bohm (1993): Markovian Queueing Systems In Discrete Time, Antonhain, Frankfurt am main.
2. N.L. Johnson and S. Kotz (1977): Urn Models and Their Application, John Wiley, New York.
3. N. L. Johnson, S. Kotz and A. W. Kemp (1992): Unvariate Discrete Distributions, Second Edition, John Wiley, New York.
4. J. Medhi (1991): Stochastic Models in Queueing Theory, Academic Press.
5. S. G. Mohanty (1979): Lattice Path Counting and Applications, Academic Press.

(c) **Design of Experiments**

Block Designs and optimality, the C-Matrix, E-optimality, A-optimality, D optimality. Plackett Burman Designs and their properties. Experimental Designs for fitting response surfaces. Design criterion involving bias and variance. Restricted Surface Methods and Taguchi's Parameter Design. Restricted Region Simplex Designs. Mixture experiments involving process variables. Weighing Designs.

Suggested Readings:

1. Bapat, R.B. (1993): Linear Algebra and Linear Models, Hindustan Book Agency Publishers,
2. Box, G.E.P. & Draper, N.R. (1989): Empirical Model-Building and Response Surfaces, John Wiley & Sons.
3. Cornell, John, A. (1990): Experiments with mixtures; Design, Models and the Analysis of Mixture data. John Wiley & Sons, New York.
4. Khuri, A. I. & Cornell, John, A. (1996): Response Surfaces: Design and Analysis, Marcel Dekker.
5. Lin, D.K. J. & Draper, N.R. (1999): Projection Properties of Placket and Burman Designs, Technometrices Vol. 34 pp.423-428.
6. Myers, R.H. and Montgomery, D.C.(1995): Response Surface Methodology, Process and Product Optimization Using design of Experiments. John Wiley & Sons, 1WC, New York.
7. Raghavarao, D. (1971): Construction and Combinatorial Problems of Design of Experiments, John Wiley & Sons, New York.
8. Shah, K.R. & Sinha, B.K. (1989): Theory of Optimal Designs, Springer Verlag, Berlin Lecture Notes in Statistics Volume 54.
9. Wang, J. C. & Wu, C.F.J. (1995): A Hidden Projection Property of Placket Burman and Related Designs. Statistics Sinica, 5, 235-250.

(d) **Design and Inference in Survey Sampling**

A general exposition of sampling schemes and designs; Role and relevance of randomization in Survey Sampling; Sufficiency and Rao-Blackwellization; Resampling techniques for variance-estimation; estimation of the population variance using auxiliary information; small area Statistics; Optimal Strategies based on different types of superpopulation models including regression model, Godambe-Joshi lower bound; Robust estimation in finite population sampling.

Suggested Readings:

1. Cassel, C-M, Sarndal, C-E and Warstman, J.H. (1977): Foundations of Inference in Survey Sampling, Wiley Inter Science, New York.
2. Chaudhari, A. and Stenger, N. (1992): Survey Sampling, Marcel Dekker, New York.
3. Chaudhari, A. and Vos, J.W.E. (1988): Unified Theory and Strategies of Survey Sampling, North-Holland, Amsterdam.
4. Hedayat, A.S. and Sinha, B.K. (1991): Design and Inference in Finite Population

Sampling, Wiley Inter Science, New York.

5. Platek, R., Rao, J.N.K. Sarndal, C.E. and Singh, M.P. (Eds, 1987): Small Area Statistics (All International Symposium), John Wiley & Sons, New York.

6. Sarndal, C-E, Swensson, B. and Wretman, J.H. (1992): Model Assisted Survey Sampling, Springer-Verlag.

7. Wolter, K. M. (1984): Introduction to Variance Estimation, Springer-Verlag.

(e) **Bayesian Inference**

Regular exponential families, conjugate and canonical conjugate analysis, weighted average form of posterior expectation, Conjugate families for samples from a multivariate normal distribution, mixtures of priors, maximal data information prior, Jeffrey's noninformative invariant priors.

Posterior distribution of correlation coefficient, bivariate regression, general linear model, one-way model and its relationship to ANOVA.

Loss functions, estimation of functions of population means and regression coefficient, Linear Bayes estimation, Emperical Bayes point estimation, estimation of the prior distribution.

Informative prediction; Regulation, optimization, caliberation and diagnosis problems.

Bayesian analysis of changing sequence of random variables, detection of a change and estimation of a change point, predication. Large sample posterior distribution; Approximate evaluation of Bayesian integrals; Lindleys approximation, Tierney-Kadane approximation.

Suggested Readings

I. Aitchison, J. and Dunsmore, I.R. (1975): Statistical Prediction Analysis, Cambridge University Press.

2. Berger, J.O. (1985): Statistical Decision Theory and Bayesian Analysis, Second Edition, Springer Verlag, New York.

3. Bemardo, J.M. and Smith, A.F.M. (1994): Bayesian Theory, John Wiley and Sons, New York.

4. Broemeling, L.D. and Tsurmi, M. (1987): Econometrics and Structural Change, Marcel Dekker, Inc. New York.

5. Lee, P.M. (1989): Bayesian Statistics; an Introduction, Oxford University Press.

6. Mariz, J.S. and Lwin, T. (1989): Empirical Bayes Methods, II Edition, Chapman and Hall, London.

7. Press, S. J. (1989): Bayesian Statistics: Principles, Models and Application, John Wiley and Sons.

8. Zellner, A. (1984): Bassic Issues in Econometrics, The University of Chicago Press, Chicago.

(f). **Order Statistics**

Conditional distributions, Order Statistics and Markov chain, Order Statistic for independent non-identically distributed variates, permanent expressions for densities of order statistics.

Discrete order statistics, Dependence structure in the discrete case, Geometric order statistics, order statistics from a without replacement sample.

Bounds and approximations for moments of order statistics, Bounds in the case of dependent variates, Approximations to moments in terms of the inverse c.d.f. and its derivatives.

Statistics expressible as maxima with applications, order statistics for exchangeable variates. Concomitants of order statistics, order statistics in estimation and hypothesis testing, Distribution-free confidence and tolerance intervals. Characterizations using order statistics.

Recurrence relations and identities for moments of order statistics from an arbitrary continuous distribution and those from some specific distributions, viz. exponential, Logistic, Normal, Half logistic, right-truncated exponential and doubly truncated exponential.

Order statistics from a sample containing a single outlier: Distributions of Order Statistics, Recurrence relations for single and product moments, Functional behaviour of order statistics in cases of location and scale-outlier models.

Asymptotic theory, the asymptotic joint distribution of sample quantiles, the asymptotic distribution of extreme values.

Suggested Readings

1. Arnold, B.C. Balakrishanan, N. and Nagaraja, H.N. (1989): Relations, Bounds Approximations for Order Statistics. Lecture Notes in Statistics, Vol., 53 Springer-Verlag.
2. Arnold, B.C., Balakrishanan, N. and Nagaraja, H.N. (1992): A First Course in Order Statistics, John Wiley.
3. David, H.A. (1981): Order Statistics (2^{nd} Ed.) John wiley.
4. Galambos J. (1987): The Asymptotic Theory of Extreme Order Statistics (2^{nd} Ed.). Krieger, F.L.
5. Gumbel, E.J. (1958): Statistics of Extremes, Columbia University Press, New York.
6. Sarhan, A.E. and Greenberg, B.G. (Eds.) (1962): Contributions to Order Statistics, Wiley, New York.

(g) **Bio-Statistics**

1. Stochastic Processes of Clinical Drug Trials.
2. Stochastic Models on fertility and human reproductive process viz. Dandekar's William Brass model, Shop's and Perrin Model, Modification of Singh's (1964) result.
3. Statistical Genetics.
4. Carrier borne epidemic model.
5. Martingales

Suggested Readings

1. Bailey, N.T.J. (1957): The Mathematical Theory of Epidemics, Griffin, London.
2. Bailey, N.T.J. (1963): Elements of Stochastic Processes with Applications to Natural Sciences, John Wiley &.Sons, London, New York, Sydney.
3. Biswas, S. (1995): Applied Stochastic Processes, New Age International Publishers Limited, Wiley Eastern Limited, New Delhi.
4. Chiang, C.L. (1968): Introduction to Stochastic Processes in Bio Statistics, John Wiley, New York.
5. Chiang, C.L. (1980): An Introduction to Stochastic Processes and Their Applications, Kreiger, New York.
6. Elandt Johnson (1971): Probability Models and Statistical Methods in Genetics, John Wiley, New York.
7. Johnson & Johnsor (1980): Survival models and Data Analysis, John Wiley & sons, New York.
8. Li, C.C. Population Genetics
9. Moran, P.A.P. (1961): Statistical Processes in Evolutionary Theory, Oxford Clarendon Press.
10. Narain Prem (1990): Statistical Genetics, Wiley Eastern Limited, New Delhi.
11. Rupert Miller (1981): Survival Analysis, Wiley Series in Probability and

Mathematical Statistics, Applied Probability and Statistics, John Wiley and Sons.

(h) **Multivariate Analysis:** Course to be given later.

(i) **Non-Parametric Methods:**

U-Statistics, Confidence Intervals and Bounds, Distribution-Free Procedures, Locations Models: One Sample; Two sample; Multivariate. Linear Rank Statistics, tests for the scale problem, Asymptotic Relative Efficiency of Tests.

Suggested Readings:

I. Gibbons, J.D. (1985): Nonparametric Statistical Inference, Second Edition, Marcel Dekker, Inc. New York.
2. Hettmansperger, T.P. (1984): Statistical Inference Based on Ranks, John Wiley Inc., New Your.
3. Randles, R.H. and Wolfe, D.A. (1979): Introduction to the Theory of Nonparametric Statistics, John Wiley Inc., New York.
4. Pun, M.L. and Sen, P.K. (1971): Nonparamétric Methods in Multivanate Analysis, John Wiley Inc., New York.
5. David, H.A. (1981): Order Statistics, Second Edition, John Wiley Inc., New York.

(j) **Reliability and Life Testing**

Reliability, hazard-rate and mean time to failure and their inter-relationships. Exponential distribution, memory less property. Maximum likelihood estimation and uniformly minimum variance unbiased estimation for the parameter and reliability function.

Gamma and Weibuil distributions. Estimation of parameters and reliability function with complete and censored samples. Estimation with regression approach. Normal and lognormal distributions-estimation of parameters and reliability with complete samples,

Tests of hypotheses and confidence intervals for the reliability function of exponential, gamma,Weibull, normal and lognormal distributions.

Bayes estimation for the parameters and reliability function (under different losses) of exponential, gamma, Weibull, normal and lognormal distributions. Lindley's expansion and its application in Bayesian reliability estimation. Bayesian credible intervals for the parameters and reliability function for exponential, gamma, Weibull, normal and lognormal distributions.

Suggested Readings

I. Bain, L.J. and Engelhardt, M. (1991): Statistical Analysis of Reliability and Life- Testing Models. Marcel Dekker Inc., U.S.A. -

2. Cohen, A.C. and Whitten, B.J. (1988): Parameter estimation in Reliability and Life Span Models. Marcel Dekker Inc., U.S.A.

3. Gerstbakh, I.B. (1989): Statistical Reliability Theory. Marcel Dekker Inc., New York.

4. Hoyland, A. and Rausand, M. (1994): System Reliability Theory: Models and Statistical Theory. Marcel Dekker Inc., New York.

5. Kalbfleisch, J.D. and Prentice, R.L. (1980): The Statistical Analysis of Failure Time Data. John Wiley and Sons, New York.

6. Lawless, J.F. (1982): Statistical Models and Methods for Lifetime Data. John Wiley and Sons Jnc.,.U.S.A.

7. Mann, N.R., Schafer, R.E. and Singpurwala, N.D. (1974): Methods for Statistical Analysis of Reliability and Life Data. John Wiley, New York.

8. Martz, H.F. and Wailer, R.A. (1982): Bayesian Reliability Analysis. John Wiley and Sons, Inc., New York.

9. Sinha, S.K. (1986): Reliability and Life-Testing. Wiley Eastern Ltd., New Delhi.

10. Sinha, S.K. (1998): Bayesian Estimation. New Age Publication.

11. Zacks, S. (1992): Introduction to Reliability Analysis. Springer-Verlag, U.S.A.