

# Department of Statistics

(School of Physical and Decision Sciences)

## SYLLABUS

FOR

# Ph. D Course Work in Statistics

(2019 onwards)

BABASAHEB  
BHIMRAO  
AMBEDKAR  
UNIVERSITY



"LUCKNOW"

विद्या विना शक्तिः  
ESTABLISHED 1988

**Babasaheb Bhimrao Ambedkar University**

(A Central University)

Vidya Vihar, Raibareli Road,

Lucknow-226025

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**Head**

**Department of Statistics**  
**School of Physical and Decision Sciences**  
 Babasaheb Bhimrao Ambedkar University, Lucknow-226025

**COURSE STRUCTURE FOR PH. D. COURSE WORK IN STATISTICS 2019 ONWARDS**

<b>Paper Code</b>	<b>Paper Title</b>	<b>Credit</b>
<b>PS 101</b>	<b>Research Methodology</b> (Every department shall offer an advanced course covering the research methodologies/philosophy (or any other relevant advanced course as decided by the DRC) of the discipline concerned. This course shall be compulsory for all students of the department concerned)	Credit-04
<b>PS 102</b>	<b>Research and Publication Ethics</b>	Credit-02
<b>PS 103 – PS 110</b>	<b>Optional paper</b> (Every eligible guide of a department shall offer one course related to his/her field to specialization. This course may have a component on reviewing of published research work in the relevant field. Students shall be free to choose one of these courses as per their research interest)	Credit-04
	<b>PS 103- Reliability Theory and Sequential Analysis</b>	
	<b>PS 104- Statistical Inference</b>	
	<b>PS 105- Sampling Theory</b>	
	<b>PS 106- Econometrics and Time Series</b>	
	<b>PS 107- Ordered Random Variables</b>	
	<b>PS 108- Sampling Design &amp; Mathematical Programming Techniques</b>	
	<b>PS 109- Stochastic Orders</b>	
	<b>PS 110- Soft Computing</b>	
<b>PS 111</b>	<b>Presentation &amp; review of literature</b>	Credit-04
<b>PS 112</b>	<b>Synopsis</b>	Credit-04
	<b>Total</b>	<b>Credit-18</b>

Each paper shall carry 100 marks the breakup of which is as follows.

- a. Written Examination: 70 marks
- b. Internal Assessment (Class performance/ Presentation): 30 marks.

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**SYLLABUS FOR Ph. D. COURSE WORK IN APPLIED STATISTICS**

**PAPER-I RESEARCH METHODOLOGY (PS-101)**

**(4 credits)**

Introduction to Statistical Research, Statistical Research Process, Statistical Research Design and Implementation, Measurement Concepts in Statistical Research, Secondary Data, Survey Research, Types of Measurement Scales: Nominal Scale, Ordinal Scale, Interval Scale, Ratio Scale – Criteria For Good Measurement, Concept of Scaling, Introduction of Qualitative Data Analysis. Use of Statistical Software and R Language.

Definition of Research, Characteristics of Research, Criteria of good Research, Research in Statistics, Meaning of Statistical Research, Need of Statistical Research, Area of Research, Advantages of Statistical Research, Limitations of Statistical Research. Research Proposal, Meaning of Research Proposal, Need and Importance of Research Proposal, Types of Research Proposal, Benefits of Research Proposal. Heuristic Research Approach, Phenomenological Research Approach, Interdisciplinary Research Approach, Ethnographical Research Approach. Research Design, Informal Research Design, Formal Research Design

Research Problem, Meaning of Research Problem, Importance of Research Problem, Steps in identifying Research Problem, Criteria of selecting Research Problem, Evaluation of Research Problem, Characteristics of Good Research Problem, Research Questions.

Meaning of Hypothesis, Criteria for Hypothesis Construction, Importance of Hypothesis, Types of Hypothesis, Testing of Hypotheses, Assumptions.

Review of Related Literature, Meaning of Review of Related Literature, Objectives of Review of Literature, Need of Review of Literature, Impact Factor. Concept of Research Tools and Techniques, Types of Research Tools and Techniques, Questionnaire, Check list, Interview Schedule, Observation. Research Report and Research Paper, Concept of Research Report and Research Paper, Purpose of Research Report and Research Paper, Norms of Research Report and Research Paper, Format of Research Report and Research Paper, Style and Language of Research Report and Research Paper, Technical aspects of Thesis/ Dissertation, Evaluation of Research Report and Research Paper, References, Appendix.

## REFERENCES:

*Pauline V Young Research Methodology*

*Kothari C. R. Research Methodology, New Age Publications, New Delhi*

## PAPER-II RESEARCH AND PUBLICATION ETHICS (PS-102)

(4 credits)

The course comprises of six modules listed in table below. Each module has 4-5 units.

Modules	Unit Title	Teaching Hours
<b>Theory</b>		
RPE 01	Philosophy and Ethics	4
RPE 02	Scientific Conduct	4
RPE 03	Publication Ethics	7
<b>Practice</b>		
RPE 04	Open Access Publishing	4
RPE 05	Publication Misconduct	4
RPE 06	Databases and Research Metrics	7
	<b>Total</b>	<b>30</b>

### Syllabus in detail:-

#### THEORY

- **RPE 01: PHILOSOPHY AND ETHICS (03 hrs.)**
  1. Introduction to philosophy: definition, nature and scope, concept, branches.
  2. Ethics: definition, moral philosophy, nature of moral judgements and reactions.
- **RPE 02: SCIENTIFIC CONDUCT (03 hrs.)**
  1. Ethics with respect to science and research.
  2. Intellectual honesty and research integrity.
  3. Scientific misconducts: falsification, Fabrication, and Plagiarism (FPP).
  4. Redundant publications: duplicate and overlapping publications, salami slicing.
  5. Selective reporting and misrepresentation of data.
- **RPE 02: PUBLICATION ETHICS (07 hrs.)**
  1. Publication ethics: definition, introduction and importance.
  2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
  3. Conflicts of interest.

4. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types.
5. Violation of publication ethics, authorship and contributorship.
6. Identification of publication misconduct, complaints and appeals.
7. Predatory publishers and journals.

## **PRACTICE**

- **RPE 04: OPEN ACCESS PUBLISHING (04 hrs.)**

1. Open access publications and initiatives.
2. SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies.
3. Software tool to identify predatory publications developed by SPPU.
4. Journal finder/journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

- **RPE 05: PUBLICATION MISCONDUCT (04 hrs.)**

**A. Group Discussions (02 hrs.)**

1. Subject specific ethical issues, FFP, authorship.
2. Conflicts of interest.
3. Complaints and appeals: examples and fraud from India and abroad.

**B. Software tools (02 hrs.)**

Use of plagiarism software like Turnitin, Urkund and other open source software tools.

- **RPE 06: DATABASE AND RESEARCH METRICS (07 hrs.)**

**A. Databases (04 hrs.)**

1. Indexing databases.
2. Citation databases: Web of Science, Scopus, etc.

**B. Research Metrics (03 hrs.)**

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score.
2. Metrics: h-index, g-index, i10 index, altmetrics.

**PAPER- III OPTIONAL PAPER**

**(4 credits)**

**PS 103- RELIABILITY THEORY AND SEQUENTIAL ANALYSIS**

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 Weibull 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.

#### **REFERENCES:**

- Bain, L.J. and Engelhardt, M. (1991): Statistical Analysis of Reliability and Life- Testing Models. Marcel Dekker Inc., U.S.A. -*
- Cohen, A.C. and Whitten, B.J. (1988): Parameter estimation in Reliability and Life Span Models. Marcel Dekker Inc., U.S.A.*
- Gerstbakh, I.B. (1989): Statistical Reliability Theory. Marcel Dekker Inc., New York.*
- Hoyland, A. and Rausand, M. (1994): System Reliability Theory: Models and Statistical Theory. Marcel Dekker Inc., New York.*
- Kalbfleisch, J.D. and Prentice, R.L. (1980): The Statistical Analysis of Failure Time Data. John Wiley and Sons, New York.*
- Lawless, J.F. (1982): Statistical Models and Methods for Lifetime Data. John Wiley and Sons Jnc., U.S.A.*
- Mann, N.R., Schafer, R.E. and Singpurwala, N.D. (1974): Methods for Statistical Analysis of Reliability and Life Data. John Wiley, New York.*
- Martz, H.F. and Wailer, R.A. (1982): Bayesian Reliability Analysis. John Wiley and Sons, Inc., New York.*
- Sinha, S.K. (1986): Reliability and Life-Testing. Wiley Eastern Ltd., New Delhi.*
- Sinha, S.K. (1998): Bayesian Estimation. New Age Publication.*
- Zacks, S. (1992): Introduction to Reliability Analysis. Springer-Verlag, U.S.A.*
- Wald A. (1947): Sequential Analysis. John Willy and sons, New York.*

#### **PS 104- STATISTICAL INFERENCE**

Properties of good estimators, Unbiasedness, Consistency, Efficiency, Sufficiency Minimal sufficient statistics and Completeness. Cramer-Rao, Bhattacharya bounds. Minimum variance unbiased estimators, Rao-Blackwell Theorem. Lehman-Scheffe theorem and their applications.

Method of Estimation, Method of Maximum Likelihood, Method of Moments, Method of Chi-Square, properties of M.L.E. Location Invariance, scale invariance. Pitmann's estimators for location and scale parameters.

Neymann – Pearson fundamental lemma – distributions with monotone likelihood ratio confidence bounds, UMP tests for the two sided hypothesis – tests for parameters in a normal distribution.

Unbiased tests: Concept of unbiasedness – application to one parameter exponential family –similarly and completeness – UMP unbiased tests for multi parameter exponential families– comparison of two Poisson and Binomial population - Application of unbiasedness.

Invariant tests: Symmetry and invariance – maximal invariance - most powerful invariant tests – unbiasedness and invariance

## **REFERENCES:**

*Lehman E.L. and Casella: Theory of Point Estimation, Springer Verlag, 1988.*

*Lehman E.L. : Testing Statistical Hypothesis, John Wiley & Sons, 1986.*

*Rohatgi V.K. : Introduction to mathematical Statistics, Wiley Eastern, 1984. Zacks S.: Theory of Statistical Inference, John Wiley & Sons, 1991 Ferguson T.S. : Mathematical Statistics - A decision theoretic approach, Academic Press, 1967.*

*Kale B. K : A first course on parametric inference, Narosa Publication, New Delhi, 1999.*

## **PS 105- SAMPLING THEORY**

Unequal probability sampling: ppswr and wor methods (including Lahiri's scheme) and related estimators of a finite population mean (Hansen-Hurwitz and Desraj estimators for general sample size and Murthy's estimator for a sample of size 2).

Horvitz-Thompson estimator, its variance and unbiased estimator of variance, IPPS schemes of sampling due to Midzuno-Sen, Rao-Hartley-Cochran and Sampford.

The Jackknife and Bootstrap : estimate of bias, estimate of variance. Ratio Estimation in reference to Jackknife and bootstraps, Relationship between the jackknife and the bootstrap. Interpenetrating sub sampling.

Successive Sampling, sampling for two occasion for estimation of population mean, population ratio etc., estimation of change in mean.

Non-sampling errors. Non response errors, Hansen Hurwitz method for tackling non response, Randomized Response techniques (Warner's method: related and unrelated questionnaire methods).

#### **REFERENCES:**

- Chaudhuri, A. and Mukerjee, R. (1988): Randomized Response: Theory and Techniques, New York: Marcel Dekker Inc.*
- Cochran, W.G.: Sampling Techniques (3rd Edition, 1977). Wiley.*
- Des Raj and Chandok (1998): Sampling Theory, Narosa.*
- Murthy, M. N. (1977): Sampling Theory & Methods, Statistical Publishing Society, Calcutta.*
- Sukhatme et al (1984): Sampling Theory of Surveys with Applications. Iowa state University Press & IARS.*
- Singh, D. and Chaudhary, F.S. (1986): Theory and Analysis of Sample Survey Designs. New Age International Publishers.*
- Gray, H.L., and Schucany(1972) : The generalized jackknife statistic. New York. Marcel Dekker, Inc.*

#### **PS 106 - ECONOMETRICS AND TIME SERIES**

Models containing function of the predictors, including polynomial models, Use of orthogonal models, Hypotheses for one and more than one linear parametric functions, Confidence regions, Analysis of Variance, Power of F-test. Multiple comparison tests due to Tukey and Scheffe, Simultaneous confidence intervals.

The general linear model (GLM) and its extensions, Use of dummy variables and seasonal adjustment, Generalized least squares (GLS) estimation and prediction, Heteroscedastic disturbances, Pure and mixed estimation, Grouping of observations and of equations.

Auto correlation, its consequences and tests, Theil BLUS procedure: estimation and prediction, Multicollinearity problem, its implications and tools for handling the problem, Ridge regression.

Linear regression with stochastic regressors, Instrumental variable estimation, Errors in variables, Autoregressive linear regression, Distributed lag models.

Time Series - General linear filter model, Autoregressive (AR(p)) models, Moving average model (MA(q)), Autoregressive, Moving average (ARMA(p,q)) models, Autoregressive integrated moving average model (ARIMA(p,d,q))

#### **REFERENCES:**

- Cook, R.D. and Weisberg, S. (1982): Residual and Influence in Regression. Chapman and Hall.*
- Draper, N.R. and Smith, H. (1998): Applied Regression Analysis, Third Edition Wiley.*
- Guest, R.F. and Mason, R.L. (1980): Regression analysis and its Applications - A Data Oriented Approach. Marcel and Dekker.*



*Rao, C.R. (1973): Linear statistical inference and its Applications. Wiley Eastern.*

*Weisberg, S. (1985): Applied Linear Regression. Wiley.*

*Anderson, T.W. (1971). The Statistical Analysis of Time Series, John Wiley, New York.*

*Box, G.E.P. and Jenkins, G.M. (1976). Time Series Analysis- Forecasting and Control, Holden-day, San Francisco.*

*Kendall, Sir Maurice and Ord, J.K. (1990), Time Series, Edward Arnold, London.*

*Fuller, W.A. (1976). Introduction to Statistical Time Series, John Wiley, New York.*

*Montgomery, D.C. and Johnson, L.A. (1977) Forecasting and Time Series Analysis, McGraw Hill, New, York.*

### **PS 107 - ORDERED RANDOM VARIABLES**

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.

### **REFERENCES**

1. David, H. A and Nagaraja H.N. : Order Statistics, John Wiley & Sons, 2004

### **PS 108 – SAMPLING DESIGN & MATHEMATICAL PROGRAMMING TECHNIQUES**

Estimation of population mean, total and proportion in SRS and Stratified sampling, estimation of gain due to stratification, methods of allocation with more than one characteristics: Chatterjee and Cochran methods, ratio and regression methods of estimation, optimality of ratio estimate, cluster sampling: estimation of population mean and their variances based on cluster of equal sizes, variance in terms of intra-class correlation coefficient, two stage sampling: estimation of population total and mean with equal first stage units, variances and their estimation, optimum sampling and sub-sampling fractions, double sampling, double sampling for stratification.

Integer Programming: Gomory's f-cut, Branch and Bound method: Branching, bounding and fathoming. Dynamic Programming: Bellman's principle of optimality, the general characteristics of Dynamic Programming Problems, Solutions of L.P. problems by D.P.

The general Nonlinear Programming Problem, difficulties introduced by nonlinearity, the Kuhn-Tucker necessary conditions for optimality, solution of simple NLPP using K-T conditions, Quadratic Programming: Wolfe's method and Beale's method.

Multi-objective Programming Problems, solutions by various distance based methods, Goal Programming, Lexicographic Goal Programming.

## REFERENCES:

- Bazara, M.S., Sherali, H.D. and Shetty, C.M. (2006): *Nonlinear Programming: theory and algorithms*, Wiley, New York.
- Cochran, W.G. (1977): *Sampling Techniques*, 3rd edition, John Wiley & Sons, New York.
- Hillier, F.S. and Lieberman, G.J. (2001): *Introduction to operations research*; McGraw-Hill, New York.
- Murthy, M.N. (1977): *Sampling theory and methods*, Statistical Publishing Society, Calcutta.
- Rao, S.S. (1984): *Optimization: theory and applications: how Michael 'selected' Amy*. Kluwer Academic Publishers, Dordrecht.
- Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and asok, C. (1984): *Sampling theory of surveys with applications*. 3rd edition, Iowa State University Press, Iowa and Indian Society of Agriculture Statistics, New Delhi.
- Taha, H.A. (2011): *Operations research: an introduction*, Ninth edition Pearson, India.
- Wagner, H.M. (1975): *Principles of Operations research: with applications to managerial decisions*: Prentice Hall Inc., N.J.

## PS 109 STOCHASTIC ORDERS

Univariate Stochastic Orders: The usual stochastic order, the hazard (reserved hazard) rate order, the likelihood ratio order, the mean residual life order, the convex (concave) order, the dispersive order, the monotone convex (concave) order, star and super-additive order.

Closure properties of these orders, different characterization and properties of these orders. Applications of these orders in reliability theory, economics, etc.

Multivariate Stochastic Orders: The usual multivariate stochastic order. The multivariate hazard rate order, the multivariate likelihood ratio order, the multivariate reversed hazard rate order. Properties and applications of these orders.

Relation between stochastic ageing and stochastic orders.

### **REFERENCES:**

- Barlow, R.E. and Proschan, F. (1975). Statistical Theory of Reliability and Life Testing. Holt, Rinehart and Winston, New York.*
- Lai, C.D. and Xie, M. (2006). Stochastic Ageing and Dependence for Reliability. Springer, New York.*
- Marshall, A.W. and Olkinn, I. (2007). Life Distributions, Springer, New York.*
- Muller, A. and Stoyan, D. (2002). Comparison Methods for Stochastic Models and Risk,. John Wiley.*
- Shaked, M. and Shantikumar, J.G. (2007). Stochastic Orders. Springer, New York.*

### **PS 110 SOFT COMPUTING:**

Introduction to Soft Computing, Historical Development, Definitions, advantages and disadvantages.

Neural Networks: Fundamentals, Neural Network Architectures, Feedforward Networks, Backpropagation Networks.

Fuzzy Logic: Fuzzy Sets, Fuzzy numbers, Fuzzy Systems, membership functions, fuzzification, defuzzification

Application of Soft Computing Techniques.

### **References:**

- Klir, G. J. and Yuan, B.: "Fuzzy Sets and Fuzzy Logic: Theory and Applications", Prentice Hall. 1995*
- Rajasekaran, S. and Vijayalakshmi Pai, G.A.: "Neural Networks, Fuzzy Logic and Genetic Algorithms: Synthesis and Applications", Prentice Hall of India. 2003*
- Sinha, N.K. and Gupta, M. M. : "Soft Computing and Intelligent Systems - Theory and Applications", Academic Press. 2000*

*Tettamanzi, A., Tomassini, M.: “Soft Computing: Integrating Evolutionary, Neural, and Fuzzy Systems”, Springer.*

**PAPER- III PRESENTATION & REVIEW OF LITERATURE (PS 111) (4 credits)**

In addition to the above two Papers, every student shall be required to submit a review of literature based on a theme/topic of his/her choice. This course may have a component on reviewing of published research work in the relevant field/ a publishable review articles.

**PAPER-IV SYNOPSIS (PS 112) (4 credits)**

Preparation and presentation of synopsis before DRC for evaluation.