CENTRAL UNIVERSITY OF HARYANA

(*Established under the Central Universities Act, 2009*)

(NAAC Accredited 'A' Grade)

Curriculum and Syllabi
Of
Ph.D. Statistics

(w.e.f. 2022-2023)

DEPARTMENT OF STATISTICS
SCHOOL OF BASIC SCIENCES

Approved by :	**BOS**	**School Board**	**Academic Council**
Approval Status :	√	√	√
Approval Date :	10-05-2022	12-09-2022	07-10-2022

COURSE WORK: Ph.D. PROGRAMME IN STATISTICS

Course Type

- Core Course
- Elective Course

Total Credits: 14

S. No.	Course Title	Course Code	Credits	Course Type
1.	Research Methodology	SBS ST 02 01 01 C 6006	6	Core
2.	Research and Publication Ethics	SBS ST 02 01 02 C 2002	2	Core
3.	Advanced Reliability Theory	SBS ST 02 01 01 E 6006	6	Elective
4.	Bayesian Inference	SBS ST 02 01 02 E 6006	6	Elective
5.	Order Statistics	SBS ST 02 01 03 E 6006	6	Elective
6.	Reliability and Life Testing	SBS ST 02 01 04 E 6006	6	Elective

Note: Students will be required to choose any one subjects from the elective courses.

RESEARCH METHODOLOGY
(SBS ST 02 01 01 C 6006)

Course Objectives:

To familiarize the students with general techniques of performing analysis of data and modelling using various simulation techniques. This course will enable students to design experiments and methods to extract data.

Learning Outcomes:

1. To motivate students for research in different fields of Physics, Mathematics and Statistics.
2. To teach students different techniques of research modelling, data collection, designing and planning of experiments.
3. To enable to analyze data and write report based on data analyzed.

UNIT I

Research Problems: Meaning, Motivation, Objectives and types of research, Significance of research, Research proposals and aspects, Criteria of good research, Research formulation and hypotheses, Selection and necessity of defining the problem, Literature review, Primary and secondary sources, Reviews, Treatise, Monographs, Patents.

UNIT II

Research Design: Need, Problem Definition, Variables, Research design concepts, Research design process, Research Modeling: Types of models, Model building and stages, Data collection, processing and analysis, Simulation techniques using computer software(s).

UNIT III

Design and Planning of Experiments: Aims and objectives, expected outcome, methodology to be adopted, importance of reproducibility of research work, Interpolation, Extrapolation, Types of errors (rounding, truncation, machine and random), Error analysis and least square curve fitting. Analysis of Variance components (ANOVA) for fixed effect model, Objectives and basic principles of designs of experiments. Complete randomized design (CRD), Randomized block design (RBD) and Latin square design (LSD).

UNIT IV

Data mining and Report Writing: Library resources, Internet, Scientific search engines, Introduction to Latex/Google docs, Structure and component of research paper, Presenting the research paper/thesis, Journal impact factor, Citation index, References and bibliography, Copyright, Plagiarism and ethics in research, Communication and presentation.

Suggested Readings:

1. Kothari, C.R & Garg, G. (2014). Research Methodology: Methods and Techniques, 3rdEdition. New Age International Publishers, New Delhi.
2. Pannerselvan, R. (2009). Research Methodology. Prentice Hall of India, New Delhi.
3. Singh, Y.K. (2008). Fundamental of Research Methodology and Statistics. New Age International Publishers, New Delhi.
4. Montgomery, D.C. (2013). Design and Analysis of Experiments, 8th Edition. Wiley India.
5. Prathapan, K. (2014). Research Methodology for Scientific Research. IK International, New Delhi.

Research and Publication Ethics
(SBS ST 02 01 02 C 2002)

End Semester Examination: 60

Internal Assessment: 40

Total: 100

Course Objectives:

The course aimed is to aware the students about the basic ethics of research and publication. The contents will serve as basic tools to groom the students about plagiarism in research.

Learning Outcomes:

On completion of the course, the student should be able to:

- Understand the basic ethics of research.
- Maintain the research integrity and intellectual honesty.
- Understand the scientific misconduct and proper citations.
- Acquire knowledge of databases and software's.

Theory

RPE 01: Philosophy and Ethics (3 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 (5 hrs.)

1. Ethics with respect to science and research

2. Intellectual honesty and research integrity

3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP)

4. Redundant publications: duplicate and overlapping publications, salami slicing

5. Selective reporting and misrepresentation of data

RPE 03: Publication Ethics (7 hrs.)

1. Publication ethics: definition, introduction and importance

2. Best practices / standards setting initiatives and guidance: 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 (4 hrs.)

1. Open access publications and initiatives

2. SHERPA/RoMEO online resource to check publisher copyright & self-archiving polices

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 (4 hrs.)

A. Group Discussion (2 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 (2 hrs.)

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

RPE 06: Databases and Research Metrics (7 hrs.)

A. Databases (4 hrs,)

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

B. Research Metrics (3 hrs.)

1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IIP, Cite Score

2. Metrics: h index, g index, i10 index, almetrics.

Suggested Readings:

1. Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance, 2019, ISBN:978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf
2. Chaddah, P., Ethics in Competitive Research: Do not get scooped; do not get plagiarized 2018, ISBN:978- 9387480865
3. Beall, J. Predatory publishers are corrupting open access, Nature, 489 (7415), 179-179, 2012. https://doi.org/10.1038/489179a
4. Resnik, D. B., What is ethics in research and why is it important, National Institute of Environmental Health Sciences, 1-10. Retrived from https://www.neihs.nih.gov/research/resources/bioethics/whatis/index.cfm 2011.
5. National Academy of Sciences, National Academy of Engineering and Institute of Medicine, On Being a Scientist: A Guide to Responsible Conduct in Research: 3 rd edition , National Academics Press 2009.
6. Bird, A., Philosophy of Science, Routledge 2006.
7. MacIntyre, A., A Short History of Ethics, London 196

ADVANCED RELIABILITY THEORY
(SBS ST 02 01 01 E 6006)

Course Objectives:

The objective of the course is to enhance the knowledge of students to understand the theory as well as practical aspects of Reliability to deal with real life system complexities.

Learning Outcomes:

1. To understand concept of Reliability and Availability also distinguish between them.
2. To measure the reliability function and mean time to failure for different types of systems.
3. To study the life Time distribution and the concept of various reliability operations on it.
4. To study the concept and Analysis of life time data.

Unit I

Introduction to Reliability: Basic concepts and Reliability Measures, Types and Importance of reliability. Failures: Different Modes of Failure, Causes of Failures, Failure Rate, Hazard Function. Reliability in Terms of Hazard Rate and Failure Density Functions. Mean Time to System Failure (MTSF), Relation between MTSF and Reliability and related research articles.

Unit- II

System Components and Configurations: Series, Parallel, Series-Parallel, Parallel-Series, and K-out-of-N systems. Redundancy**:** Types of Redundancies, Repairable Systems, Coherent Structure: min paths and cut sets, modular decomposition, lower/upper bounds on system reliability. Reliability and Structural importance of components, Maintenance Policies; Availability: Definition and Types and related research articles.

Unit –III

Classes of Life distribution: IFR, IFRA, NBU and NBUE Classes and their duals, Closures of these classes under various reliability operations, Reliability of Safety Systems, Safety instrumented Systems, Probability of failure on Demand, Safety Unavailability, Common Cause Failures **and related research articles.**

Unit IV

Life Data Analysis: Concept of Censoring and its types, Reliability Estimation based on Failure Times in Censored Life Tests: Kaplan–Meier Estimation, Hazard Plotting Techniques, Maximum Likelihood Estimation and Probability Plotting Technique. Two-Unit Cold Standby and Parallel-Unit Systems with Constant Failure Rate, Arbitrary Repair Rates and a Single Server using Semi-Markov Process and Regenerative Point Technique **and related research articles.**

Suggested Readings:

1. Rausand, M., & Hoyland, A. (2009). System reliability theory: Models, statistical methods, and applications (2nd edition). Hoboken, NJ: Wiley-Interscience.
2. Barlow, R. E., & Proschan, F. (2007). Statistical theory of reliability and life testing: probability models. New York: Holt, Rinehart and Winston.
3. Balagurusamy, E. (2017). Reliability Engineering, Tata McGraw-Hill Education.
4. Birolini, A. (2017). Reliability Engineering, Springer-Verlag Berlin Heidelberg.

BAYESIAN INFERENCE
(SBS ST 02 01 02 E 6006)

Course Objectives:

The objective of this course is to provide the sound knowledge of Bayesian estimation and the lifetime distribution methodology to students for the estimation regarding reliability characteristics of systems.

Learning Outcomes:

1. Describe the role of the posterior distribution, the likelihood function, prior and the posterior distribution about a parameter in Bayesian framework.
2. Understand inferences for lifetime models in Bayesian framework.
3. Learn the basic concepts of nonparametric techniques.
4. Understand the sequential probability ratio test and its application.

UNIT I

Prior distribution, subjective determination of prior distribution. Improper priors, non-informative (default) priors, invariant priors **and related research articles.**

UNIT II

Conjugate prior families, construction of conjugate families using sufficient statistics of fixed dimension, mixtures of conjugate priors **and related research articles.**

UNIT III

Parametric Empirical Bayes. Bayesian inference: Bayes sufficiency, summary through posterior, predictive inference. Bayesian decision theory: Bayes solutions for practical decision problems. Point estimation, credible sets. Comparison with classical procedures **and related research articles.**

UNIT IV

Bayesian calculation, Monte-Carlo Integration and Markov chain Monte Carlo techniques (without proof) **and related research articles.**

Suggested Readings:

1. Berger, J. O. (2013). Statistical Decision Theory and Bayesian Analysis. Springer.
2. Robert, C.P. & Casella, G. (2013). Monte Carlo Statistical Methods. Springer.
3. Kelly, D. & Smith, C. (2011). Bayesian Inference for Probabilistic Risk Assessment: A Practitioner's Guidebook. Springer.
4. Jeliazkov, I. & Yang, X.S. (2014). Bayesian Inference in the Social Sciences. Wiley.

ORDER STATISTICS
(SBS ST 02 01 03 E 6006)

Course Objectives:

The objective of the course is to learn general strategies for problems about order statistics and how to learn to find the median (or k-th largest) in linear average-case number of comparisons (and time).

Learning Outcomes:

1. Understand the basic concepts of order statistics, joint, marginal and conditional probability distributions of order statistics.
2. Learn about distribution-free confidence intervals for population quantile and distribution-free tolerance intervals for population distributions.
3. Construct the recurrence relations and identities for moments of order statistics.
4. Enhanced with the concepts of distributions of order statistics for independently and not identically distributed variates and also for dependent variates.

UNIT I

Order statistics and their distributions and properties. Discrete & continuous joint, marginal and conditional distributions of order statistics. Censoring and progressive censoring, order statistics for independent and non-identically distributed variates. Example based on continuous distributions **and related research articles.**

UNIT II

Moments of order statistics, Large sample approximations to mean and variance of order statistics. Asymptotic distributions of order statistics, Recurrence relations and identities for moments of order statistics **and related research articles.**

UNIT III

Confidence intervals for distribution quantiles, tolerance limits for distributions. Asymptotic distribution of function of sample moments, U-Statistics, Transformation and Variance stabilizing results **and related research articles.**

UNIT IV

Generalized order statistics: distribution of generalized order statistics. Joint, marginal and conditional distribution of generalized order statistics. Moments and recurrence relations. Characterization of continuous distributions through conditional moments and recurrence relations of generalized order statistics. Review of latest literatures **and related research articles.**

Suggested Readings:

1. Shahbaz, M.Q., Ahsanullah, M., Shahbaz, S.H. & Al-Zahrani, B.M. (2016). Ordered Random Variables: Theory and Applications. Springer.
2. David, H.A. & Nagaraja, H.N. (2005). Order Statistics, 3rd Edition. Wiley.
3. Ahsanullah, M., Nevzorov, V.B. & Shakil, M. (2013). An Introduction to Order Statistics, Atlantis Studies in Probability and Statistics, Vol. III. Atlantis Press.
4. Arnold, B.C., Balakrishnan, N. & Nagaraja, H.N. (2008). A First Course in Order Statistics. SIAM Publishers.

RELIABILITY AND LIFE TESTING
(SBS ST 02 01 04 E 6006)

Course Objectives:

The objective of this course is to provide lifetime distribution methodology to students for the estimation and testing of hypotheses regarding reliability characteristics of systems.

Learning Outcomes:

1. Understand basic concepts of reliability and life testing models.
2. Learn how to handle censored data under different scenarios.
3. Understand the testing of hypothesis and confidence interval for different life time models.
4. Learn how to obtain the Bayes estimators.

UNIT I

Definition of reliability function, hazard function, mean time to system failure and their relationship. Life testing plans or censoring methods, right and left censoring, Type I and II censoring schemes **and related research articles.**

UNIT II

Exponential, Gamma, Weibull and normal probability models as used in the analysis of life time data and in problems related to the modeling of aging or failure processes. Estimation of parameters and reliability function associated with various life time distributions and life testing plans, Various properties of these estimators **and related research articles.**

UNIT III

Test of hypothesis and confidence intervals for the parameters and reliability function of exponential, gamma, Weibull and normal distributions **and related research articles.**

UNIT IV

Bayes estimators of the parameters and reliability function under different loss functions associated with various life time distributions. Their properties and comparison with classical estimators **and related research articles.**

Suggested Readings:

1. Deshpande, J.V. & Purohit, S.G. (2016). Life Time Data: Statistical Models and Methods, 2nd Edition. Word Scientific.
2. Lawless, J.F. (2011). Statistical Models and Methods for Lifetime Data, 2nd Edition reprint. Wiley.
3. Zacks, S. (2011). Introduction to Reliability Analysis - Probability Models and Statistical Methods. Springer.
4. Lee, E.T. & Wang, J.W. (2015). Statistical Methods for Survival Data Analysis, 4th Edition. Wiley.