Department of Statistics, M.D. University, Rohtak
Scheme of Examination for Ph.D. Course Work Program in Statistics
w.e.f. 2023-24
(Under NEP-2020)

Semester -I

Course and Code	Course Name	Credits	Marks	Internal Assess.	Total Marks
23STAPH11C1	Research Methodology	L-4	70	30	100
23CCPH11C1	Research and Publication Ethics	L-2	35	15	50
Optional Paper - 1					
23STAPH11C2	Reliability Theory and Modelling	L-4	70	30	100
OR					
23STAPH11C3	Regression Analysis and Bayesian Inference	L-4	70	30	100
Optional Paper - 2					
23STAPH11C4	Information Theory	L-2	35	15	50
OR					
23STAPH11C5	Fuzzy Set Theory	L-2	35	15	50
TOTAL		**12**	**---**	**---**	**300**

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Research Methodology
Offered in Semester: I

Course Code	23STAPH11C1	**Course Credits**	4 (L: 4 T: 0 P: 0)
Max. Marks	100 {External (term-end exam) – 70} (Internal – 30)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Objectives:

Students will Able:

- To Understand Some Basic Concepts of Research and its Methodologies.
- To Identify Appropriate Research Topics.
- To Select and Define Appropriate Research Problem and Parameters.
- To Understand the Review of Literature.
- To Provide Skills for Writing a Research Report and Thesis.

Course Outcomes:

Students:

- Able to Understand Basic Concepts of Research and Its Methodologies.
- Gained the Knowledge to Find the Scores Located on the Scale of Measurements, Validity and Reliability.
- Understand the Methodology for Writing a Research Project Proposal.
- Able to Understand Review of Literature.
- Able to Use the Technique for Random Numbers Generation.

Unit - I

Research Methodology: Introduction, Types and Significance of Research. Research Approaches. Research and Scientific Methods, Research Process, Research Problem and Criteria of Good Research, Features of a Good Research Design. Sampling Design: Characteristics of a Good Sample Design and Determination of Sample Size.

Unit – II

Data Collection: Methods of Data Collection, Case Study Method, Questionnaires and Schedules, Interviewing. Measurement and Scaling Techniques: Meaning of Scaling, Measurement Scales, Test of Second Measurements. Scale Classification Bases, Important Scaling and Scale Construction Techniques, Reliability and Validity of Measurements. Generating Data from Standard Discrete and Continuous Distributions. Exploring Univariate and Multivariate Data Using Tables and Plots. Graphical Methods of Clustering (Chernoff Faces)

Unit – III

Documentation and Scientific Writing: Meaning & Techniques of Interpretation, Precautions in Interpretation, Preparation & Presentation of Manuscript of a Research Paper and Thesis Writing. Research Report: Presentation, Structure, Components, Types-Research Papers, Thesis, Research Project Report, Pictures & Graphs, Citation Styles and Bibliography.

Unit – IV

Databases: indexing databases, Citation databases – Web of Science, Scopus, etc. Research Metrics: Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score. Metrics – h-index, g-index, i10 Index, Altmetrics.

Suggested Readings:

1. Kothari, C.R. (2004).Research Methodology (Methods and Techniques). New Age International.
2. Panneerselvam, R. (2013). Research Methodology. Prentice Hall India Learning Private Limited.
3. Anderson, J., Dursten, B.H. & Poole, M. (1989).Thesis and Assignment Writing. John Wiley & Sons.
4. Khanzode, V.V. (2003).Research Methodology (Techniques and Trends). Aph Publishing Corporation.
5. Goon, A.M., Gupta, M.K., & Gupta B.D. (2016). Fundamentals of Statistics (Vol-I & II). World Press.
6. Tukey, J. (1977). Exploratory Data Analysis. Pearson.

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Research and Publication Ethics
Offered in Semester: I

Course Code	23CCPH11C1	**Course Credits**	2 (L:2 T: 0 P: 0)
Max. Marks	50 {External (term-end exam) – 35}(Internal – 15)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of mark one) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 07 marks each from all the four units.

Course Objectives:

Students will able:

- To Study the Philosophy of Ethics.
- To Study the Scientific Conduct of Research.
- To Study the Publication Ethics.
- To Know about Various Journal Citation Databases.
- To Know the Importance of Quality Publications.

Course Outcomes:

Students:

- Acquired the Fundamental Knowledge of Basics of Philosophy of Science and Ethics, Research Integrity, Publication Ethics.
- Able to Identify Research Misconduct and Predatory Publications.
- Able to Use Indexing and Citation Databases, Open Access Publications, Research Metrics.
- Acquainted with Plagiarism Tools for a Valid and Ethical Research Report.
- Able to Write Research and Review Articles.

Unit - I

Introduction to Philosophy: Definition, Nature and Scope, Concept, Branches. Ethics: Definition, Moral Philosophy, Nature of Moral Judgments and Reactions, Ethics w.r.t. Science and Research, Intellectual Honesty and Research Integrity. Science Misconducts: Falsification, Fabrication and Plagiarism (FFP).

Unit – II

Redundant Publications: Duplicate and Overlapping Publications, Salami Slicing. Selective Reporting and Misrepresentation of Data. Publication Ethics: Definition, Introduction and Importance. Best Practices/Standard Setting Initiatives and Guidelines: COPE, WAME, etc. Conflict of Interest.

Unit – III

Publication Misconduct: Definition, Concept, Problems that lead to Unethical Behavior and vice-versa, Types. Violation of Publication Ethics, Authorship and Contributorship. Identification of Publication Misconduct, Complaints and Appeals. Predatory Publishers and Journals.

Unit – IV

Open Access Publishing: Open Access Publications and Initiatives, SHERPA/RoMEO Online Resource to Check Publisher Copyright & Self-archiving Policies, Software Tool to Identify Predatory Publications Developed by SPPU, Journal Finder/Journal Suggestion Tool viz. JANE, Elsevier Journal Finder, Springer Journal Suggester, etc. Use of Plagiarism Software like Turnitin, Urkund and other Open Source Software Tools

Suggested Readings:

1. Bird, A. (1998). Philosophy of Science. Routledge.
2. MacIntyre, A. (1998). A Short History of Ethics. University of Notre Dame Press.
3. Chaddah, P. (2018). Ethics in Competitive Research - Do not Get Scooped; Do not Get Plagiarized. Self Published.
4. Resnik, D.B. (2015). What is Ethics in Research & Why is it Important. National Institute of Environmental Health Sciences, 1-10.
5. Muralidhar, K., Ghosh, A. & Singhvi, A.K. (2019). Ethics in Science, Research and Governance. Indian National Science Academy.

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Reliability Theory and Modelling
Offered in Semester: I

Course Code	23STAPH11C2	**Course Credits**	4 (L:4 T: 0 P: 0)
Max. Marks	100 {External (term-end exam) – 70}(Internal – 30)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Objectives:

Students will able:

- To Understand the System Reliability Problems.
- To Know about the Different Hazard Models.
- To Understand the Procedure for Evaluating Reliability Measures.
- To Acquire Knowledge about Different Systems Structures.
- To Study System Reliability Models Using Markov Process Approaches.

Course Outcomes:

Students:

- Able to Understand the Techniques of Reliability Prediction.
- Acquired Knowledge to Analyze Statistical Experiments Leading to Reliability Modelling.
- Able to Apply Reliability Theory for the Assessment of Reliability in Engineering Design.
- Acquainted with the Applications of Stochastic Processes in Reliability Theory.
- Gained Knowledge to Develop System Reliability Models.

Unit - I

Reliability: Origin and Development of Reliability, Importance of Reliability and its Types. Failures and Failure Modes. Causes of Failures. Failure Rate. Hazard Function. Reliability in Terms of Hazard Rate and Failure Density Functions. Hazard Models: Constant, Linear & Non-Linear, Weibull, Gamma and Normal Models. Markov Model. Estimation of Reliability and Failure Density Functions of Hazard and Markov Models. Mean Time to System Failure (MTSF). Relation Between MTSF and Reliability.

Unit – II

System and System Structures: Series, Parallel, Series-Parallel, Parallel-Series, Non-Series-Parallel, Mixed Mode and K-out-of-n. Evaluation of MTSF and Reliability of The System Structures. Determination of Reliability of Systems by Decomposition, Cut-Set, Event Space, Path Tracing and Boolean Function Methods.

Unit – III

Estimation of Reliability using Redundancy and Maintenance Techniques. Repairable and Non-Repairable Systems. Availability Functions. Estimation of Parametric and Non-Parametric Renewal Function. Renewal Theoretical Approach for Availability Evaluation of a System. Economics of Reliability Engineering: Manufactures & Customers Costs, Reliability Achievement, Utility and Depreciation Cost Models. Availability Cost Model for a Parallel System.

Unit – IV

Markovian Approach for estimation of Reliability and Availability of a Parallel-Unit System with Repair. Reliability and Availability Analysis: Single Unit System, Cold & Warm Standby Systems (Two-units) and Parallel-Unit Systems with arbitrary distributions for Failure & Repair Rates and a Single Server using Semi-Markov Process and Regenerative Point Technique. The Idea of Supplementary Variable Technique.

Parameters Estimation of Exponential, Gamma, Weibull, Normal and Lognormal Distributions (Two and Three Parameters) with Complete, Truncated and Censored Samples. K-out-of-n Reliability Estimation with Order Statistics.

Suggested Readings:

1. Balagurusamy, E. (2017). Reliability Engineering. McGraw Hill Education.
2. Srinath, L.S. (2005). Reliability Engineering. East West.
3. Elsayed, E.A. (2012). Reliability Engineering. Wiley.
4. Sinha, S.K. (1987). Reliability and Life Testing. Wiley–Blackwell.
5. Birolini, A. (2007). Reliability Engineering (Theory and Practice). Springer.

6. Ebeling, C. (2017). An Introduction to Reliability and Maintainability Engineering. McGraw Hill Education.

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Regression Analysis and Bayesian Inference
Offered in Semester: I

Course Code	23STAPH11C3	**Course Credits**	4 (L:4 T: 0 P: 0)
Max. Marks	100 {External (term-end exam) – 70}(Internal – 30)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of marks 02) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 14 marks each from all the four units.

Course Objectives:

Students will able:

- To Teach Students About Different Types of Regressions.
- To Aware the Students About the Use of Bayes' Rule to Transform Prior Probabilities into Posterior Probabilities
- To Acquire Knowledge to Explain the Bayesian Frame Work for Data Analysis.
- To Demonstrate the Role of Prior Distribution in Bayesian Inference.
- To Enhance Knowledge to use Bayesian Methods for Solving Real Life World Problems.

Course Outcomes:

Students:

- Able to Understand the Different Types of Regression.
- Gained Knowledge to Explain the Bayesian Frame Work for Data Analysis.
- Able to Demonstrate the Role of Prior Distribution in Bayesian inference.
- Get Enhanced Knowledge to use Bayesian Methods for Solving Real Life World Problems.
- Acquired Knowledge for Solving Real Life Problems Using Bayesian Approaches.

Unit - I

Matrix Approach to Linear Regression, R2 and Adjusted R2 , Model Adequacy Checking – Residual Analysis, Methods of Scaling Residuals- Standardized and Studentized Residuals, PRESS Residual, Residual Plots, PRESS Statistic, Variance Stabilizing Transformation, Analytical methods for Selecting a Transformation

Unit – II

Generalized and Weighted Least Squares. Diagnostics for Leverage and Influence, Variable Selection and Model Building, Computational Techniques for Model Selection- Mallow's Cp, Stepwise Regression, Forward Selection, Backward Elimination. Elementary Ideas of Logistic and Poisson regression.

Unit – III

Concepts of Prior and Posterior Distributions and Non – Informative and Improper Priors. Bayes' Theorem and Computation of Posterior Distributions, Standard Loss functions, and Concept of Bayes' Estimation, Mixture Distributions, Sufficient Statistics, Exponential Family of Distributions.

Unit – IV

Natural Conjugate Family of Priors for a Model, Conjugate Families for Exponential Family Models, Jeffrey's Prior, Asymptotically Locally Invariant Prior. Maximum Entropy Priors and Associated Bayes' Estimation.

Suggested Readings:

1. Montgomery, D.C., Peck, E.A. & Vining, G.G. (2012). Introduction to Linear Regression Analysis. Wiley.
2. Draper, N.R. & Smith, H. (1998). Applied Regression Analysis. Wiley-Interscience.
3. Robert, C.P. (1997). The Bayesian Choice: A Decision Theoretic Motivation. Springer.
4. Berger, J.O. (1993). Statistical Decision Theory and Bayesian Analysis. Springer.
5. Dobson, A.J. (2001), An Introduction to Generalized Linear Models, Chapman and Hall/CRC.

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Information Theory
Offered in Semester: I

Course Code	23STAPH11C4	**Course Credits**	2 (L:2 T: 0 P: 0)
Max. Marks	50 {External (term-end exam) – 35}(Internal – 15)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of mark one) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 07 marks each from all the four units.

Course Objectives:

Students will able:

- To Learn the Principles and Applications of Information Theory in Communication System.
- To Define and Apply the Basic Concepts of Information Theory.
- To Learn the Construction of Optimal Codes and Various Encoding Procedure.
- To Learn Channel Capacity and Decoding Schemes in Communication System.
- To Learn Applications of Entropy Function in Statistics.

Course Outcomes:

Students:

- Acquired Knowledge of Information Theory in Communication System.
- Acquired Knowledge of Entropy, Conditional Entropy, Joint Entropy, Information Measures and their Properties for both Discrete and Continuous Case.
- Acquired Knowledge to use Entropy Function in Noiseless Coding and Construction of Optimal Course.
- Acquired Knowledge of Channel Capacity and Decoding Scheme.
- Acquired Knowledge to use Entropy.

Unit - I

Basic Concepts of Information Theory, Measure of Uncertainty and its Properties, Measure of Information for two Dimensional Discrete and Continuous Finite Probability Scheme, Uniqueness of Entropy Function, Joint and Conditional Measure of Uncertainty, Interpretation of Uncertainty Measure, Measure of Mutual Information.

Unit – II

Noiseless Coding, Uniquely decipherable Codes, Instantaneous Codes, Condition for Uniquely Decipherable and Instantaneous Codes, Noiseless Coding Theorem, Optimal Codes, Block Coding, Construction of Optimal Codes, Shannon Fano encoding, Huffman Procedure.

Unit – III

Discrete Memoryless Channel, Channel matrix, Channel Capacity, Classification of Channels, Channel Capacity for Different Types of Channel, Fundamental Theorem of Information Theory(without proof), Efficiency and Redundancy, Decoding Schemes ,The Ideal Observer, Exponential Error Bound, Fano Inequality.

Unit – IV

Inequalities of Information Theory, Kullback-Leibler Measure of Information, Mean Information for Discrimination and Divergence and Their Properties, Fisher Information, Information and Sufficiency, Minimum Discrimination Information-Sufficient Statistics.

Suggested Readings:

1. Ash, R.B. (2012). Information Theory. Dover Publications.
2. Reza, F.M. (2003). An Introduction to Information Theory. Dover Publications Inc.
3. Mathai, A.M. & Rathie, P.N. (1975). Basic Concepts in Information Theory and Statistics. Wiley Eastern Pvt. Ltd.
4. Kullback, S. (1997). Information Theory and Statistics. Dover Publications Inc.
5. Stone, J.V. (2015) Information Theory : A Tutorial Introduction, Sebtel Press.

Name of the Department/Centre/Institute: STATISTICS
Name of the Major Course: Fuzzy Set Theory
Offered in Semester: I

Course Code	23STAPH11C5	**Course Credits**	2 (L:2 T: 0 P: 0)
Max. Marks	50{External (term-end exam) – 35}(Internal – 15)	**Time of end term examination**	3 Hours

Note: The examiner will set nine questions in all into five sections A, B, C, D, and E of the question paper from all the four units - I, II, III and IV of the syllabus. The candidate must attempt five questions in all selecting at least one question from each section. The question given in section A is compulsory comprises 08 short answer type questions two from each unit (each of mark one) and out of which the student will be required to attempt any 07 questions. In the remaining sections B, C, D and E there will be two questions of 07 marks each from all the four units.

Course Objectives:

Students will Able:

- To Introduce the Theory of Fuzzy Sets and Fuzzy Relations.
- To Discuss Theoretical Differences between Fuzzy Sets and Classical Sets.
- To Study Arithmetic Operations on Fuzzy Sets.
- To Introduce Generalized Fuzzy Sets and Their Properties.
- To Learn the Applications of Fuzzy Sets in Decision Making.

Course Outcomes:

Students:

- Understand the Basic Knowledge of Fussy Sets and Generalized Fuzzy Sets.
- Acquired the Knowledge about Fuzzy Relation.
- Gained the Skills to Apply Fuzzy Information in Decision Making.
- Obtained the Knowledge to Deal with Vague, Imprecise and Uncertain Problem Taking Processes.
- Abled to Apply Arithmetic Operations on Fuzzy Sets.

Unit - I

Fuzzy Sets and Uncertainty: Certainty versus Uncertainty, Fuzzy Sets and Membership Functions, Properties of Fuzzy Sets, Operations on Fuzzy Set: Union, Intersection, Algebraic Sum, Bounded Sum and Bounded Difference, Algebraic Product.

Unit – II

Convex Combination, Extension Principle, t-norm and t-Conorm Operation. Operations on Intervals, Fuzzy Numbers and Operations. Various Techniques of De-fuzzification of Fuzzy Numbers, Fuzzy Equations, Fuzzy Relations: Fuzzy Relation on Crisp Set, Fuzzy Relation on Fuzzy Set, Composition of Fuzzy Relations.

Unit – III

Max-min, Max-product, Max-average. Fuzzy Equivalence Relations, Fuzzy Antisymmetric Relation, Similarity Relation, Fuzzy Ordering Relation and Fuzzy Compatibility Relation, Fuzzy Morphism, Fuzzy Relation Equation.

Unit – IV

Generalized Fuzzy Sets: Intuitionistic Fuzzy Sets, Linguistic Fuzzy Sets, Interval Valued Fuzzy Sets, Interval Valued Intuitionistic Fuzzy Sets, Hesitant Fuzzy Set, Pythagorean Fuzzy Set, Fuzzy Rough Sets, Fuzzy Soft Sets and their Properties. Application of Fuzzy Set in Multicriteria Decision Making.

Suggested Readings:

1. Zimmerman, H.J. (1996): Fuzzy Set theory and Its Application. Springer.
2. Mohan, C. (2019): An Introduction to Fuzzy Set Theory and Fuzzy Logics. MV Learning.
3. Klir, G.J. & Yuan, B. (1995): Fuzzy Set & Fuzzy Logic: Theory and Applications. Pearson.
4. Klir, G.J. & Fegler, T.A. (1987): Fuzzy Sets, Uncertainty & Information. Pearson Education.
5. Bhargav, A.K. (2013): Fuzzy Set Theory Fuzzy Logic and Their Applications. S. Chand
6. Ross, T.J. (2011): Fuzzy Logic with Engineering Applications. Wiley.