Ph.D. Entrance Test Syllabus for Ph.D in Statistics

The PET (Ph.D. Entrance test) for Ph.D. in Science (All Branches) consists of two parts:

• Part I: Research Methodology (50 marks) and

• Part II: Subject Specific (Related to the branch for 50 marks)

Total Marks for PhD Entrance Test: 100 Marks

The Syllabus for Research Methodology is common to all branches of Science

SYLLABUS

Part I: Research Methodology (50 Marks)

1) Foundation of Research: Meaning, Objectives, Motivation, Utility. Concept of theory, Empiricism, deductive and inductive theory. Characteristics of scientific method - Understanding the language of research - Concept, Construct, definition, Variable. Research Process.

2) Problem Identification & Formulation: Definition and formulating the research problem, Necessity of defining the problem, Importance of literature review in defining a Problem, Research Question - Investigation Question - Measurement Issues - Hypothesis-Qualities of a good hypothesis - Null hypothesis & Alternative Hypothesis. Hypothesis Testing - Logic & importance.

3) Research Design: Concept and Importance in Research - Features of a good research Design - Exploratory Research Design - Concept, Types and uses, Descriptive Research Design - concept, types and uses. Experimental Design - Concept of Independent &Dependent variables.

4) Qualitative and Quantitative Research: Qualitative - Quantitative Research - Concept of Measurement, causality, generalization, replication. Merging the two approaches.

5) Data Collection and analysis: Execution ofthe research -Observation andCollection of Data - Methods of data collection, hypothesis-testing - Generalization and Interpretation.

6) Measurement: Concept of measurement- what is measured? Problem in measurement In research - Validity and Reliability. Levels of measurement - Nominal, Ordinal, Interval, Ratio.

7) Sampling: Concept of Statistical population, Sample, Sampling Frame, Sampling Error, Sample size, Non- Response. Characteristics of a good sample. Probability Sample -Simple Random Sample, Systematic Sample, Stratified Random Sample & Multi-stage Sampling. Determining size of the sample – Practical considerations in sampling and Sample size.

8) Data Analysis: data Preparation - Univariate analysis (frequency tables, bar charts, pie Charts, percentages), bivariate analysis - Cross tabulations and Chi-square test including testing hypothesis of association.

9) Interpretation of Data and Paper Writing: Layout of a Research Paper, Journals in Computer Science, Impact factor of journals, When and where to publish? Ethical issues Related to publishing, Plagiarism and Self-Plagiarism. Use of Encyclopaedias, Research Guides, Handbook etc., Academic databases for concerned discipline.

10) Use of tools / techniques for Research: Methods to search required information Effectively, Reference Management Software like Zotero/Mendeley, Software for paper Formatting like Latex/MSOffice, Software for detection of plagiarism.

11) Reporting and Thesis writing: Structure and components of scientific reports - Types of Report - Technical Reports and Thesis - Significance - Different steps in the preparation - Layout, Structure and Language of typical reports - Illustrations and Tables -Bibliography, Referencing and Footnotes – Oral presentation - Planning - Preparation -Practice - Making presentation - Use of visual aids - Importance of effective Communication.

12) Application of results and ethics: Environmental impacts - Ethical issues – Ethical committees - Commercialization - Copyright - Royalty - Intellectual property rights and Patent law - Trade related aspects of intellectual property Rights - Reproduction of Published material - Plagiarism - citation and acknowledgement citation and Acknowledgement-Reproducibility and accountability.

13) Reasoning and Mental ability: Analogy, Classification, Series, Coding-Decoding, Direction Sense, Representation through Venn Diagrams, Mathematical Operations, Arithmetical Reasoning, Inserting the Missing Character, Number, Ranking and Time Sequence Test, Eligibility Test, Representation through Venn-diagrams, Number &Symbols ordering, Comprehension questions, Statement & assumptions, Statement &Conclusions, Statement & actions.

Books Recommended;

1) Research Methodology - C. R. Kothari

2) Research Methodology: An Introduction - Stuart Melville and Wayne

3) Practical Research Methods -Catherine Dawson

4) Select references from the Internet

ReferenceBooks:

1) Garg, B. L., Karadia, R., Agarwal, F. and Agarwal, U. K., 2002. An introduction to Research Methodology, RBSA Publishers.

2) Kothari,C.R., 1990.ResearchMethodology:Methods andTechniques. NewAge International. 418p.

3) Sinha, S.C. and Dhiman,A.K., 2002. Research Methodology, EssEssPublications. 2Columns.

4) Trochim, W. M. K., 2005. Research Methods: the concise knowledge base, Atomic Dog Publishing. 270p

5) Wadehra, B. L. 2000. Law relating to patents, trademarks, copyright designs and Geographical indications. Universal Law Publishing.

For Additional Reading:

1) Anthony,M.,Graziano,A.M. and Raulin, M.L., 2009.Research Methods: A Process of Inquiry, Allyn and Bacon.

2) Carlos,C. M., 2000. Intellectual property rights, the WTO and developing countries: the TRIPS agreement and policy options. Zed Books, New York.

3) Coley, S. M. and Scheinberg, C. A., 1990,"ProposalWriting", Sage Publications.

4) Day, R. A., 1992. How to Write and Publish a Scientific Paper, Cambridge University Press.

5) Fink, A., 2009. Conducting Research Literature Reviews: From the Internetto Paper. Sage Publications

6) Leedy, P. D. and Ormrod, J. E., 2004 Practical Research: Planning and Design, Prentice Hall.

7) Satarkar, S. V., 2000. Intellectual property rights and Copyright. EssEss Publications

Part II: Statistics (50 Marks)

1.Linear Algebra

Vector space, subspace, linear dependencies and independencies, orthogonal basis, Gram-Smith orthogonalazation process, Special types of matrices: symmetric, idempotent, orthogonal matrix etc. System of linear equations. Eigenvalues and eigenvectors, Caley-Hamilton Theorem, spectral value decomposition. G-inverse, Moore-Penrose inverse. Quadratic form.

Reference Books:

1) Rao A. R. &Bhimashankaram P. (1992) : Linear Algebra. Tata Mc-Graw Hill, New Delhi.

2) Searl S. B.(1982) : Matrix Algebra Useful for Statistics-Wiley

3) Graybill , F.A (1961) : An introduction to linear Statistical models Vol-I McGraw-Hill Book company Inc.

4) Rao C. R. (1973) : Linear Statistical Inference and Its Applications , Second Edition Wiley Eastern.

2. Descriptive statistics

Frequency distribution, Graphical representation of data, Measures of central tendency, dispersion, skewness, kurtosis.

Reference Books

1) Gupta, S. C., & Kapoor, V. K. (2020). *Fundamentals of mathematical statistics*. Sultan Chand & Sons.

2) Goon, A.M., M. K. Gupta and B. Das Gupta (2002) Fundamentals of Statistics- Vol. I., World Press, Ltd, Kolkata.

3 Basic Probability and Distribution Theory

Random experiments, Sample space, Events and their types, Mathematical, Statistical and axiomatic approach of probability, Conditional probability, Bayes theorem.

Random variable: Continuous & discrete R.V.'s, Probability mass function (pmf), probability density function (pdf), Distribution function and its properties, Two dimensional random variables, conditional distribution. Functions of RV's: Distribution function technique, Univariate and bivariate transformation. Expectation and variance and their properties, Moment generating function (mgf) and its properties. Continuous distributions: Uniform, exponential, normal, beta, gamma, Cauchy, Laplace, t, Chi-square. Discrete distributions: Bernoulli, Binomial, Geometric, Poisson, Hyper-geometric, negative binomial, multinomial.

Refernce Books

1) Ross, S. M., Ross, S. M., Ross, S. M., Ross, S. M., & Mathématicien, E. U. (1976). *A first course in probability* (Vol. 2). New York: Macmillan.

2) Hogg, R. V., Tanis, E. A., & Zimmerman, D. L. (1977). *Probability and statistical inference* (Vol. 993). New York: Macmillan.

3) Rohatagi V.K.&Saleh A. K. Md. E.(2001) : Introduction to Probability Theory and Mathematical Statistics- John Wiley and sons Inc.

4) Casella & Berger (2002) : Statistical Inference - Duxbury advanced series. IInd edition

Dasgupta, A. (2010) Fundamentals of Probability: A First Course (Springer)

4. Statistical Inference

Unbiasedness, consistency, sufficiency. Neyman factorization criterion, completeness. Minimum variance bound estimator, C-R inequality, Rao-Blackwell Theorem, Lehmann-Scheffe theorem, Uniformly minimum variance unbiased estimators. Method of Maximum Likelihood, Method of moment, Interval estimation, Tests of hypothesis, concepts of critical regions, test functions, two kinds of errors, size function, power function, level, MP and UMP test, non-parametric tests.

Reference Books:

1) Hogg RV., Craig, A. & McKean JW. (2005). Introduction to Mathematical Statistics, Ed. 6, Pearson.

2) Kale, B.K. (1999). A First Course on Parametric Inference, Narosa Publishing House.

3) Lehmann, E.L. (1986). Theory of Point Estimation, John Wiley & Sons.

4) Lehmann, E.L. (1986). Testing Statistical Hypotheses, John Wiley & Sons.

5) Rao, C.R. (1973). Linear Statistical Inference and its Applications, 2nd Edn., Wiley Eastern Ltd., New Delhi.

6) Rohatgi, V.K. and Saleh, A.K. Md. E. (2005). An Introduction to Probability and Statistics, Second Edition, John Wiley.

7) Biswas, S. (2002). Topics in Statistical Methodology, New Age International Pub., New Delhi.

5. Stochastic Processes

Types of the Stochastic Processes, Markov chain, transition probabilities matrix, Chapman-Kolmogrove equation, n-step transition probabilities matrix, stationary distribution, classification of the states, Poisson process, pure birth process, pure death process, pure birth-death process, branching process.

Reference Books:

1) Medhi J. (2009): Stochastic Process, (New Age International Publications)

2) Feller W.(2008): An Introduction to Probability Theory and Its Applications. (Wiley) .

3) Taylor H. M. and Karlin S. (2014): An Introduction to Stochastic Modeling (Academic Press)

4) Ross S. (1996): Stochastic Processes. (Wiley)

5) Ross S. (2014): Introduction to Probability Models. (Academic Press)

6. Design of Experiments

Analysis of Variance: Introduction, assumptions for ANOVA, One-way ANOVA, Two-way ANOVA, estimation of parameters, expectations of various sum of squares. Role, historical perspective, terminology, experimental error, basic principles, uniformity trials, Basic designs: Completely Randomized Design (CRD), Randomized Block Design (RBD), Latin Square Design (LSD) layout, model and statistical analysis, relative efficiency. Factorial design: Basic definitions and principles, Advantages, main effect and integration effects, 22, 23, 23factorial designs, Confounding in factorial designs, complete and partial confounding,

2^n factorial design conducted in 2^k blocks. Fractional factorial designs: One-half fraction and One-quarter fraction of 2^n designs, Alias structure of designs, resolution of designs.

Reference Books

1) Gupta, S.C. and V.K. Kapoor (2010) Fundamentals of Applied Statistics, Sultan Chand & Sons, New Delhi

2) Douglas C Montgomery (2013): Design and Analysis of Experiments, 8th Ed., Wiley India.

3) Dean and Voss (2013): Design and Analysis of Experiments, Springer New York.

7 Sampling Techniques

Concepts and distinct features of probability sampling and non – probability sampling schemes, sampling designs and sampling error. SRSWOR and SRSWR related to the estimation of population mean/total and proportions. Stratified sampling and allocation problem in stratified random sampling, systematic sampling, cluster sampling. Ratio, regression and product estimators under simple rando sampling as well as in double sampling. Unequal probability sampling: PPSWR/PPSWOR methods of sample selection and comparison with SRSWR schemes. Horvitz Thompson's, Yates and Grundy, πPS sampling scheme and some of its important results. Midzuno-Sen sampling scheme. Non-sampling errors, response and non-response errors, Hansen and Hurwitz's model and their treatments, randomized response, Warner's model.

Reference Books:

1) Gupta, S.C. and Kapoor, V. K.: Fundamentals of Applied Statistics, S. Chand and Sons, New-Delhi.

2) Cochran, W. G.: Sampling Techniques, Wiley Eastern Ltd., New-Delhi. 3.

3) Sukhatme, P.V. and Sukhatme, B. V.: Sampling Theory of 4. Surveys with Applications, Indian Society Agricultural Statistics, New Delhi.

4) Murthy, M.N.: Sampling Methods, Indian Statistical Institute, Kolkata.

5) Mukhopadhyay, Parimal: Theory and Methods of Survey Sampling, Prentice Hall.

6) Singh, S. (2003). Advanced Sampling Theory with Applications: How Michael"" Selected"" Amy (Vol. 2). Springer Science & Business Media

8. Multivariate Analysis

Multivariate normal distribution- marginal and conditional distribution, characteristic function, properties of multivariate normal distribution, and distribution of quadratic forms, correlation matrix. Samples from multivariate normal distribution, MLE of mean vector and dispersion matrix. Wishart distribution: definition and properties. Hoteling's T2 and Mahalanobis' D2 distribution and properties. Discrimination and Classification problems, Principal components, extraction of principal components, canonical variables and canonical correlation, factor analysis and cluster analysis.

References:

1) Anderson, T. W. (1983): An Introduction to multivariate statistical analysis. 2nd Ed

2) Wiley. Giri, N. C. (1977): Multivariate Statistical inference. Academic Press.

3) Kshirsagar, A. M. (1972): Multivariate Analysis. Marcel Dekker.

4) Morrison, D. F. (1976): Multivariate statistical methods. 2nd. Ed. McGraw Hill.

5) Muirhead, R. J. (1982: Aspects of multivariate statistical theory, J. Wiley.

6) Rao, C. R. (1973: Linear statistical inference and its applications. 2nd Ed. Wiley.

7) Seber, G. A. F. (1984): Multivariate observations. Wiley.

8) Sharma, S. (1996: Applied multivariate techniques. Wiley.

9) Srivastava, M. S. and Khatri, C. G. (1979): An introduction to multivariate statistics.

9. Regression Analysis

Simple linear regression: the least squares estimators and properties, testing the overall regression, individual parameters, confidence intervals for the parameters and expected value of the response. Multiple linear regression model: Gauss-Markov setup, the least squares estimators and properties, testing overall regression, individual coefficients, subset of coefficients, confidence interval for the parameters and expected value of the response variable, R^2 adjusted R^2. General linear models. Non full rank model: Gauss-Markov setup, best linear unbiased estimator, estimability of parameters. Residual analysis, subset selection. Generalized linear regression models: logistic regression, Poisson regression.

Reference Books

1) Montgomery, D. C., Peck, E. A. and Vining, G. G. (2003). Introduction to Linear Regression Analysis, Wiley

2) Draper, N. R. and Smith, H. (1998). Applied Regression Analysis, John Wiley, Third Edition

3) Weisberg, S. (2005). Applied Linear Regression, Wiley.

4) Yan, X. and Su, X. G. (2009). Linear Regression Analysis: Theory & Computing, World Scientific

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