Department of Statistics
Siksha-Bhavana
Visva-Bharati University

PhD Course Work – one semester course.

Course-1: (a) Research Methodology and Techniques- 75 marks (3 Credit Points)

Importance of Research in Decision Making	(2L)
Defining Research Problem and Formulation of Hypothesis	(2L)
Experimental Designs	(8L)
Methods and Techniques of Data Collection	(2L)
Sampling and Sampling Designs	(8L)
Knowledge of Computer Software e.g. S-Plus, R, Matlab, Minitab, etc	(20L)
Data Processing	(4L)
Statistical Analysis and Interpretation of Data	(8L)
Multivariate Analysis of Data	(8L)
Technical Aspects of Thesis writing	(2L)

References

Kothari, C.R.(1985): Research Methodology – Methods and Techniques (Wiley Eastern)
Montgomery, D. C. (1976): Design and Analysis of Experiments (Wiley)
Johnson, R. & Wichern (1992): Applied Multivariate Statistical Analysis (Prentice-Hall)
Cochran, W. G. (1984): Sampling Techniques (Wiley)

(b) Basics of Computer Applications – 25 marks (1 Credit Points)

This is to be framed and implemented by Department of Computer and System Sciences, Siksha-Bhavana

Course-2: Recent Advance in the relevant field of research-100 marks (4 Credit Points)

Any one of the following will be offered in consultation with the Supervisor.

Course-301: Statistical Process and Quality Control
Course-302: Advanced Reliability Analysis
Course-303: Statistical Ecology
Course-304: Advanced Design of Experiments
Course-305: Applied Nonparametric Statistical Methods
Course-306: Geostatistics

More modules will be incorporated as and when necessary.

Course-3: Review work in the relevant field of Research and Seminar Presentation-100 marks (4 Credit Points)

Dissertation-60% marks
Presentation-20% marks
Viva-voce-20% marks

DETAILED SYLLABUS

Course-301

STATISTICAL PROCESS AND QUALITY CONTROL

Basic concept of process monitoring and control, process capability and process optimization (8L)
General theory and review of control charts for attribute and variable data; O.C. and A.R.L. of control charts; control by gauging; Moving average and exponentially weighted moving average charts; Cu-sum charts using V-masks and decision intervals; Economic design of X-bar chat (15L)
Acceptance sampling plans for attribute inspection; single, double and sequential sampling plans and their properties; Plans for inspection by variables for one-sided and two-sided specifications; Mil Std and IS plans; Continuous sampling plans of Dodge type and Wald-Wolfiwitz type and their properties. Bayesian sampling plans. (15L)
Capability indices: Cp, Cpk and Cpm; estimation, confidence intervals and tests of hypotheses relating to capability indices for Normality distributed characteristics. (8L)
Use of Design of Experiments in SPC; factorial experiments, fractional factorial designs, construction of such designs and analysis of data, Taguchi's concept of design (23L)
Multivariate quality control; use of control ellipsoid and of utility functions (8L)

References

Montgomery, D. C. (1985): Introduction to Statistical Quality Control (Wiley)
Montgomery, D. C. (1985): Design and Analysis of Experiments (Wiley)
Ott, E. R. (1975): Process Quality Control (McGraw Hill)
Phadke, M. S. (1989): Quality Engineering through Robust Design (Prentice Hall)
Wetherill, G. B. (1977): Sampling Inspection and Quality Control (Halsted Press)
Wetherill, G. B. and Brown, D. W. (): Statistical Process Control, Theory and Practice (Chapman and Hall)

Course-302

ADVANCED RELIABILITY ANALYSIS

Reliability estimation based on failure time in various censored life tests. Stress-strength reliability and its inferential aspect. (15L)
Univariate shock models and life distribution arising out of them. Bivariate shock models, common bivariate exponential distribution and their properties. (10L)
Maintenance and replacement policies; availability of repairable systems; modeling of a repairable system by a non-homogeneous Poisson process. (7L)
Different measures of Entropy and their properties, Information Theory and Reliability (23L)
Basic ideas of accelerated life testing and basic ideas of software reliability. (10L)

References

Barlow R.E. and Proschan F. (1985): Statistical Theory of Reliability and Life testing (Holt, Rinehart and Winston)
Lawless J.F. (1982): Statistical model and Methods of Life time data (John Willey)
Bain L.J. and Engelhardt (1991): Statistical Analysis of Reliability and Life testing Models (Marcel Dekker)
Nelson, W. (1982): Applied Life Data Analysis (John Willey)
Kotz, S., Lumelskii, Y. and Pensky, M. (2003): The Stress-Strength Model – Theory and Applications (World Scientific Publishing)

Course-303

STATISTICAL ECOLOGY

Introduction to Ecology and evolution (4L)
Population dynamics: single species – Exponential, logistic and Gompertz models, Leslie matrix model for age and stage structured population, Survivorship curves – Constant, monotone and bath tub shaped hazard rates (16L)
Two species: Lotka – Volterra equations, isoclines, competition and coexistence, predator-pray oscillations (10L)
Abundance estimation: Capture – recapture, Nearest neighbour, line transect sampling, indirect methods (16L)
Ecology Diversity: Species abundance curve, Indices of diversity (Simpson's index, Shannon – Wiener index), Diversity as average rarity (6L)
Harvesting renewable biological resources – Maximum sustainable yield, tragedy of the commons (6L)
Game theory in ecology – Evolutionary stable strategy, its properties, simple games such as Hawk – Dove game (6L)
Foraging theory: Optimal foraging, diet choice, mean variance trade-off (6L)

References

Anil Gore and S. A. Paranjpe (2000): A course on Mathematical and Statistical Ecology (Kluwer)
Clark, C. W. (1976): Mathematical Bioeconomics: Optimal Management of Renewable Resources (Wiley)
Maynard Smith, J. (1982): Evolution and the Theory of Games (Cambridge University Press)
Pielou, E. C. (1977): An Introduction to Mathematical Ecology (Wiley)
Seber, G. A. F. (1982): Estimation of Animal Abundance and Related Parameters (Charles Griffin)
Stephens, D. W. and Krebs, J. R. (1986): Foraging Theory (Princeton University Press)

Course-304

ADVANCED DESIGN OF EXPERIMENTS

Fractional Plans and Orthogonal Arrays**:** Introduction, Kronecker Calculus, Fractional Factorial Plans, Concept of Resolution, Optimality Criteria, Role of Orthogonal Arrays (10L)

Symmetric Orthogonal Arrays: Orthogonal Arrays and Hadamard Matrices, Foldover Technique, Use of Galois Fields, Method of Differences and Related Results (10L)

Asymmetric Orthogonal Arrays: Collapsing and Replacement Procedures, Use of Hadamard Matrices, Use of Difference Matrices, Use of Resolvable Arrays, Arrays of Higher Strength (10L)

More on Optimal Fractional Plans and Related Topics: Augmented Orthogonal Arrays-Addition of One Run, Augmented Orthogonal Arrays-Further Results, Nearly Orthogonal Arrays, Optimality with Two or Three Factors (5L)

Supersaturated Designs: Introduction, Two-level Supersaturated Designs and their Optimality Criteria, Multi-level Supersaturated Designs and their Optimality Criteria, Notion of Uniform Designs, Construction of Optimal Supersaturated Designs, Notion of Probability of Correct Searching of Supersaturated Designs, Probability Optimal two-level Supersaturated Designs, Probability Optimal Multilevel Supersaturated Designs (15L)

Search Designs: Notion of Search Designs and the Concept of Resolving Power of a Design, Necessary and Sufficient Condition For the Existence of Two-level Search Designs, Necessary and Sufficient Condition For the Existence Multi-level Search Designs, Construction of Two-level Search Designs, Construction of Multi-level Search Designs, Concept of Probability of Correct Searching (15L)

References

Atkinson, A. C. and Donev, A. N. (1992): Optimal Experimental Designs (Oxford University Press)

Chakrabarty, M. C. (1962): Mathematics of Design of Experiments (Asia Publ. House)

Cornell, M. (1963): Mixture Experiments (Wiley)

Dey, A. and Mukerjee, R (1999): Fractional Factorial Design (Springer)

Khuri, A. and Cornell. M. (1991): Response Surface Methodology (Marcel Dekker)

Pukelsheim, F. (1993): Optimal Design of Experiments (Wiley)

Raghavarao, D. (1971): Construction and Combinatorial Problems in Design of Experiments (Wiley)

Shah, K. R. and Sinha, B. K. (1989): Theory of Optimal Designs (Springer-Verlag)

Course-305

APPLIED NONPARAMETRIC STATISTICAL METHODS

Introduction of nonparametric methods, U statistics and its distribution, single sample tests, sign test etc, methods of paired sample, methods of two independent tests, correlation and concordance [8L]

categorical data, Association in categorical data, Some models for contingency tables [4L]

nonparametric regression, smoothing technique, kernel smoothing, spline smoothing, cubic spline, quintic spline, spline on spline interpolation [10L]

partial linear model, shape-invariant modelling, cross validation [4L]

Recapitulation of parametric classification technique: cluster analysis, discriminant analysis, decision tree [4L]

adaptive nonparametric clustering, discriminant analysis, classification using spline, Nonlinear class boundaries by spline, Neural Network, CART. [20L]

Reference:

1. Gibbons, J.D.(2003) Nonparametric Statistical Inference 4th edition, Marcel Dekker Inc.
2. Hardle, W. (1994) Applied Nonparametric Regression, Cambridge University Press.
3. Johnson, R.A. & Wichern, D.W.(1988), Applied Multivariate Statistical Analysis,Sixth Edition, Pearson inc.
4. Kloke, J. & Mckien, J. W. (2015) Nonparametric Statistical Methods Using R, Chapman & Hall/CRC
5. Muller, M. & Hardle, W. (2004), Nonparametric and semiparametric models, Springer.

Course-306

GEOSTATISTICS

Basic concepts of Geostatistics and spatial data, Spatial Covariance, Correlation and Semivariance. Plotting of spatial data with special emphasis on Indian context viz. Indian Summer Monsoon rainfall, temperature etc. Interpolation of spatial data and Kriging.
Stochastic simulation – generation of multiple equi-probable images of the variables e.g. precipitation, temperature etc.
Concepts of short-term, medium range and seasonal forecasting of weather variables (precipitation, temperature etc.). Forecast skill evaluation. Forecast verification techniques. Ensemble forecasts and it's errors, ensemble spread, relation between ensemble forecast errors and ensemble spread. Forecasts using Bayesian Model Average.
Statistical downscaling: Markov model, Hidden Markov Model and their usefulness.
Overview of Statistical problems in climate.

References:

E.H. Isaaks and R.M. Srivastava, 1989, An Introduction to Applied Geostatistics, Oxford University Press.
D. S. Wilks, 2006, Statistical methods in the atmospheric sciences, 2ed. Elsevier.
R.A. Olea, 1999, Geostatistics for Engineers and Earth Scientists, Kluwer Academic Publishers.

Applications of Statistics to Modeling the Earth's Climate System, 1994, NCAR Technical Note.