

PhD (Statistics) Program
Semester wise Scheme of Study

1. PhD students will have to take 18 teaching credit hours from the following list for PhD program in first two semesters.
2. The PhD students must complete the minimum required teaching credit hours in first 2 years with two core courses mentioned in the list.
3. The PhD students cannot take the course(s) which he/she has already taken at M.Phil./MS level.
4. The courses will be offered depending on the availability of faculty.

PhD Courses		
Course Code	Course Title	Credit Hours
STA-736*	Advanced Sampling Techniques	3(3-0)
STA-737	Advanced Econometric Analysis	3(3-0)
STA-738*	Generalized Linear Models	3(3-0)
STA-739	Advanced Probability Theory	3(3-0)
STA-740	Advanced Response Surface Methodology	3(3-0)
STA-741	Applied Stochastic Models	3(3-0)
STA-742	Bayesian Decision Theory	3(3-0)
STA-743	Mixture Distributions	3(3-0)
STA-744	Advanced Statistical Computing	3(3-0)

* Core courses compulsory to qualify for PhD degree

Other mandatory requirement for PhD

Year-II Semester - III & IV		
Course Code	Course Title	Credit Hours
STA-758	Seminar-I	1 (0-1)
STA-759	Seminar-II	1 (0-1)
STA-760	Thesis	

Eligibility Criterion for PhD:

1. All candidates fulfilling the admission criterion of Government College University, Faisalabad will be eligible to apply.

**Detailed Course outline for Courses that can be taken during PhD
(Statistics) Program**

STA-736 Advanced Sampling Techniques 3(3-0)

Steps and problems involved in planning and conduct of census and sample surveys. Selection and estimation procedures, description and properties of simple random sampling, description and properties of stratified random sampling, formation of strata, different methods of allocation sample size, ratio and regression estimates in simple and stratified random sampling, estimation of mean using Searls estimators, exactly unbiased ratio type estimators, power transformation, Srivenkataramana (1980) and Bandhopadhyaya (1980) dual ratio estimators, Redely estimators, Bedi estimators, exponential type of ratio estimator, different forms of ratio, product and regression type estimators, randomized response models, probability proportional to size.

Recommended Books

- Lohr, S. L. (2019). Sampling Design and Analysis. 2nd edition, CRC, Press, Taylor and Francis group, USA.
- Hanif, M. Shahbaz, M. Q. and Ahmad, M. (2018). Sampling Techniques: Methods and Applications. Nova Science Publisher, Inc USA.
- Thompson, S. K. (2012). Sampling. 3rd edition, John Wiley and Sons, New York.
- Mukhopadhyay, P. (2005). Theory and Methods of Survey Sampling. Prentice-Hall of India.
- Des Raj and Chandhok, P. (1998), Sample Survey Theory. Narosa Publishing House, New Delhi.
- Cochran, W. G. (1996). Sampling Techniques. 3rd edition, John Wiley and Sons, New York.

STA-737 Advanced Econometric Analysis 3(3-0)

Econometric modeling; stochastic assumptions of econometrics; simple and multiple regression analysis; ordinary least squares, maximum likelihood and method of moments estimators of parameters of the classical general linear regression model; heteroscedasticity, autocorrelation, multicollinearity and endogeneity: structure, causes, consequences and tests for detection; two-stage least squares (2SLS) and instrumental variables least squares estimators; the simultaneous equation model; model selection: choice of variables and choice of functional form, Hausman test; models for dichotomous and polychotomous response variables, log linear models, logit, probit and multinomial logit models. Application of econometric modeling in different fields: labour economics, wage functions, labour force participation, the estimation of demand

and supply equations; estimation of production relationship; estimation of pricing equations; econometric methods for financial data, linear regression tests of financial models, efficient portfolio and capital asset pricing model, .

Recommended Books

- Studenmund, A. H. (2017). A Practical guide to using Econometrics. 7th edition. Pearson Education Limited UK.
- Greene, W. H. (2017). Econometric Analysis. 8th Edition, Prentice Hall.
- Gujarati, D. N. (2010). Basic Econometrics. 5th Edition, McGraw-Hil.
- Wooldridge, J. M. (2010). Econometric Analysis of Cross Section and Panel Data. 2nd Edition, The MIT Press.
- Brooks, C. (2008). Introductory Econometrics for Finance. 2nd Edition, Cambridge University Press.
- Cameron, A. C. and Trivedi, P. K. (2005). Microeconometrics: Methods and Applications. Cambridge University Press.

STA-738

Generalized Linear Models

3(3-0)

Logistic and Poisson regression: Logit model for dichotomous data with single and multiple explanatory variables, ML estimation, large sample tests about parameters, goodness of fit, analysis of deviance, variable selection, extension to polytomous data, introduction to Poisson regression. Linear models for two and three dimensional contingency tables: interpretation of parameters, comparison with ANOVA and regression, ML estimation of parameters, likelihood ratio tests for various hypotheses including independence, marginal and conditional independence, partial association, models with quantitative levels.

Nonparametric regression and generalized linear models: interpolating and smoothing splines for simple regression, use of cross-validation, applications to logistic and Poisson regression introduction to additive models and generalized additive model.

Recommended Books

- Dunn, P.K. and Smyth, G.K. (2018). Generalized linear models with examples in R. New York, NY: Springer.
- Homer, D.W. and Lemeshow, S. (2013). Applied Logistic Regression. 3rd Edition, Wiley, New York.
- Agresti, A. (2012). Categorical Data Analysis. 3rd Edition, Wiley, New York.
- McCullough, P. and Nadler, J.A. (1999). Generalized Linear Models. 2nd Edition, Chapman and Hall, London.

- Christensen, R. (1997). Log-linear Models and Logistic Regression. 2nd Edition, Springer, New York.
- Green, P.J. and Silverman, B.W. (1994). Nonparametric Regression and Generalized Linear Models. Chapman and Hall, London.

STA-739

Advanced Probability Theory

3(3-0)

Algebra of sets, fields and sigma-fields, limits of sequences of subsets, sigma-field generated by a class of subsets, Borel fields. Probability, measure on a sigma-fields, probability space, continuity of a probability measure. Real and vector-valued random variables, distribution functions (d.f.), independent r.v.s., convolution, discrete r.v.s., r.v.s of the continuous type, decomposition of a.d.f., independence of two events and ($n > 2$) events, sequence of independent events, independent classes of events. Sampling transformation of random variables and their distributions. Non central chi-square, t and F distributions. Distribution of Fisher's Z statistics and linear sample correlation coefficient for uncorrelated normal data. Limiting Distributions: some families of distributions Pearson, Johnson, and Burr families, Dynkin's theorem, independence of r.v.s, Borel zero-one law. Expectation of a real r.v. and of a complex-valued r.v. Linear properties of expectations, characteristic functions, their simple properties, uniqueness theorem. Convergence of a sequence of r.v.s., convergence in distribution, convergence in probability, Kolmogorov strong law of large numbers (without proof), monotone convergence theorem and dominated convergence theorem, continuity theorem for characteristic functions. Lindeberg's CLT and its particular cases, Cramer's theorem on composition of convergence in distribution and convergence in probability. Characteristics function of Distribution in R^k . Independence of mean vector and the quadratic form of normal variables.

Recommended Books

- [Emanuel Parzen](#) (2013) Modern Probability Theory and Its Applications
- Billingsley, P. (2012), Probability and Measure. 3rd Ed. Wiley, New York.
- Bhat, B.R. (1999). Modern Probability Theory. Wiley Eastern.
- Stuart, A. and Ord, J. K. (1998). Advanced Theory of Statistics, Vol-I: Distribution Theory. 6th Edition, Edward Arnold.
- Jaynes, E.T. (1995). Probability Theory: The Logic of Science. Washington University Press. Publisher : Literary Licensing, LLC

Response surface methodology. First, and second-order RS designs. Fitting of response surface models and estimation of optimum response. Desirable properties of a response surface design; Experimental designs for fitting response surfaces. Central composite designs and their variations, Box-Behnken designs, subset designs, Small response surface designs: small composite designs.

Robust response surface designs; Orthogonal designs; Rotatable designs; Orthogonal blocking in response surface designs; Practical design optimality criteria: D-, Ds, A-, As-, G, Gs- Optimality. Tradeoff between different optimality criteria; Graphical procedures for evaluating the estimation capability of a response surface design: variance dispersion graphs, fraction of design space plots. Some new response surface designs for the estimation of a second-order multivariate polynomial model; Response optimization through mixture experiments.

Recommended Books

- Myers, R. H., Montgomery, D. C., & Anderson-Cook, C. M. (2016). Response surface methodology: process and product optimization using designed experiments. John Wiley & Sons.
- Montgomery, D.C. (2012). Design and Analysis of Experiments, 8th Ed. Wiley, New York.
- Oehlert, G. W. (2010). A First Course in Design and Analysis of Experiments, University of Minnesota.
- Atkinson, A. C., Donev, A. N. and Tobias, R. D. (2007). Optimum Experimental Designs, with SAS, Oxford University Press.
- Box, G.E.P. and Draper, N.R. (2007). Response Surfaces, Mixtures and Ridge Analyses. 2nd Edition, Wiley Series in Probability and Statistics.
- Khuri, A. I. (2006). *Response surface methodology and related topics*. World scientific.
- Berger, M.P.F. and Wong, W.K. (2005). Applied Optimal Designs, Wiley, New York.
- Khuri, A.I. (2005). Response Surface Methodology and Related Topics, Washington, DC: World Sciences.
- Wu, H. and Wu, C.F.J. (2002). Experiments: Planning, Analysis, and Parameter Design Optimization, Wiley, New York.
- Box, G.E.P., Hunter, W.G. and Hunter, J.S. (1978). Statistics for Experimenters: An Introduction to Design, Data Analysis, and Model Building. Wiley, New York.

STA-741

Applied Stochastic Models

3(3-0)

Probability generating, functions, compound distributions, simple random walk, branching processes, Markov process, discrete and continuous time Markov chains, birth-death process, immigration and emigration process, immigration-death processes, renewal processes, Markov renewal process, Ergodic theorem, Gaussian processes and Brownian motion.

Recommended Books

- GRIMMETT, G. S. (2020). Probability and random processes. Oxford university press.
- Ross, S. M. (2014). Introduction to probability models. Academic press.
- Gallager, R. G. (2013). Stochastic processes: theory for applications. Cambridge University Press.
- Fader, P.S. and Hardie, B.G.S. (2006). An Introduction to Applied Probability Models. Johann Wolfgang Goethe-Universität, Frankfurt.
- Melhi, J. (1982). Stochastic Processes. Wiley, New York.
- Stirzaker, D.R. (1982). Probability and Random Processes. Oxford University Press, London.
- Cox, D.R. and Miller, H.D. (1972). The Theory of Stochastic Processes. Chapman and Hall.
- Feller, W. (1968). An Introduction to Probability Theory and its Applications, Vol-1. 3rd Edition., Wiley, New York.

STA-742

Bayesian Decision Theory

3(3-0)

Utility theory; The utility of money; Rewards; Consequences; The loss functions; Development of the loss function from the utility theory; Certain standard loss functions for inference and predictive problems. Bayes estimators; Bayes predictors; Bayesian hypothesis testing under the different loss functions. Decision function; Multivariate loss function with Bayesian estimation. Risk; Types of risk. Choice of a sample size under posterior Bayes risk.

Books Recommended

- McNamara, T. P., and Chen, X. (2020). Bayesian Decision Theory and Navigation. PsyArXiv. <https://doi.org/10.31234/osf.io/zduca>
- Reich, B. J., and Ghosh, S. K. (2019). Bayesian Statistical Methods. CRC Press, Taylor & Francis Group.

- Berger, J. O. (2013). Statistical decision theory and Bayesian analysis. Springer Science & Business Media.
- Black-well and Grishick M.A., Theory of Games and Statistics Decisions, John Wiley and Sons Inc. New York, (1996).
- O' Hagan A, Kendall's Advanced Theory of Statistics (V2B) Bayesian Inference, University Press: Cambridge, (1994).

STA-743

Mixture Distributions

3(3-0)

Statistical Applications, Mathematical aspects: identifiability, multimodality, general properties. Estimating mixing parameters: graphical methods, method of moments, maximum likelihood and Bayesian estimation.

Determining the number of components of a mixture. Informal techniques, formal techniques for special cases and general formal techniques. Modality: analytical structure and assessment. Approximate solutions for: mixing parameters and component parameters in classical and Bayesian framework.

Books Recommended

- Bouguila, N., & Fan, W. (Eds.). (2020). Mixture Models and Applications. 1st Edition. Springer.
- Borelli Zeller, C. (2018). Finite Mixture of Skewed Distributions. 1st Edition. Springer.
- Geoffrey, J. M., David, P., Finite mixture Models. John Wiley & Sons (2001).
- Bruce L., Mixtures models: Theory, geometry and applications, institute of mathematical statistics (1995).
- Everitt, B. S. and Hand, D. J., Finite Mixture Distributions, Chapman & Hall, (1981).
- Titterington, D. M., Smith, A. F. H. and U. E. Markov, Statistical Analysis of Finite Mixture Distributions, John Wiley & Sons (1986).

STA-744

Advanced Statistical Computing

3 (3-0)

Introduction to R as a language and environment for statistical computing and graphics. Manipulations of numbers, vectors and matrices. Importing/exporting data from/to different other statistical software's. A general overview of built-in R functions. Linear regression and diagnostics in R, Likelihood maximization. Use of different add-on packages. Handling output in R. Introduction to programming in R and hands-on experimentation demonstrating the common techniques like repeated sampling,

resampling methods like Jackknife, bootstrapping, Gibbs sampling. Generating random numbers, simulating normal, gamma and beta random variables. Monte Carlo simulation, Building simulation models, variance reduction and statistical validation techniques. Work on replicating the simulation results of 2-3 published articles.

Overview different other Statistical and Mathematical packages like Minitab, E-views, Mathematica, Matlab, SAS etc. of Introduction to different reference management software's like endnote, mendeley etc. Introduction to writing/formatting using Latex.

Books Recommended

- Different online tutorial for Latex and other reference management software's.
- Different Online tutorials for R in general and for specific for some tasks in R
- Hui, E. G. M., Hui, E. G. M., & John, S. (2019). *Learn R for Applied Statistics*. Apress.
- Tattar, P. N., Ramaiah, S., & Manjunath, B. G. (2016). *A Course in Statistics with R*. John Wiley & Sons.
- Crawley, M. J. (2012). *The R Book*, 2nd Edition. Wiley.
- Maindonald, J., & Braun, W. J. (2010). *Data Analysis and Graphics Using R: An Example-Based Approach*, 3rd Edition. Cambridge University Press.
- Robert, C.P. & Casella, G. (2010). *Monte Carlo Methods with R*. Springer
- Cohen, Y., & Cohen, J. Y. (2008). *Statistics and Data with R: An Applied Approach Through Examples*. Wiley.
- Dalgaard, P. (2008). *Introductory Statistics with R*. 2nd Edition. Springer.