Department of Statistics, Biostatistics & Informatics
University of Dhaka
Syllabus for PhD. in Statistics, Biostatistics & Informatics
Sessions: 2010-2011, 2011-2012, 2012-2013, 2013-2014 and 2014-2015

A student admitted to the Ph,D. program will have to undertake full time study at the department under the guidance of his/her supervisor(s). The Ph,D. degree shall consist of (a) written examinations on approved courses, (b) submission of a thesis on an approved topic and (c) an oral examination. The department will offer a number of courses in the first year of Ph.D. from which a student will have to take courses covering 8 credits (200 marks) recommended by the respective supervisor(s). There will be written and viva voce examinations on the approved courses at the end of the year, the pass marks for which will be 50 per cent. In addition, the student will be required to carry out research on specific topic approved by the supervisor(s) in the 2nd year. Then, the student will submit a thesis with the written approval of the supervisor(s). Finally, the student will have to appear at an oral examination provided that his/her thesis is recommended for acceptance by the examiners.

Courses Offered for Ph.D Program

Course No.	Title	Credits
Stat PhD-701	Advanced Statistical Inference	4
Stat PhD-702	Advanced Multivariate Analysis	4
Stat PhD-703	Advanced Robust Methods	4
Stat PhD-704	Advanced Econometrics	4
Stat PhD-705	Advanced Demography & Population Studies	4
Stat PhD-706	Advanced Design of Experiments	4
Stat PhD-707	Advanced Biostatistics	4
Stat PhD-708	Advanced Sampling Theory	4
Stat PhD-709	Advanced Analysis of Planned Experiments	4
Stat PhD-710	Advanced Statistical Meta-Analysis	4
Stat PhD-711	Asymptotic Methods in Statistical Inference	4

Detailed Course Materials

Stat PhD-701: Advanced Statistical Inference

4 Credits

Probability integral transformation, non-uniqueness of moments, convergence of moment generating functions, differentiating under an integral sign, bivariate transformations, hierarchical models and mixture distributions, numerical and functional inequalities.

Order statistics, convergence concepts, the delta method, generating a random sample – direct methods, indirect methods, the accept/reject algorithm.

Sufficiency principle, likelihood principle, equivariance principle.

Methods of finding estimators, the EM algorithm; methods of evaluating estimators, loss function optimality, robust estimation.

Methods of finding tests, methods of evaluating tests, most powerful tests, sizes of union-intersection and intersection-union tests, p-values, loss function optimality, nonparametric tests, robust tests.

Methods of finding interval estimators, methods of evaluating interval estimators, test-related optimality, Bayesian optimality, loss function optimality, robust confidence intervals.

Asymptotic evaluations of point estimation, hypothesis testing and interval estimation.

One-way analysis of variance: inferences regarding linear combinations of means, simultaneous estimation of contrasts, partitioning sums of squares; Simple linear regression: estimation and prediction at a specified value of predictor, simultaneous estimation and confidence bands.

Regression with errors in variables, logistic regression, robust regression.

Text

2. Casella, G. and Berger, R.L. (2002), *Statistical Inference*, Duxbury Advanced Series, N.Y.

References

5. Lehmann, E.L. and Casella, G. (1998), *Theory of Point Estimation.* 2nd Ed., Springer-Verlag New York.
6. Lehmann, E.L. and Romano, J.P. (2005), *Test of Hypothesis.* 3rd Ed., Springer Science, New York.
7. Rao, C.R. (1984), *Linear Statistical Inference and its Application*, 2nd Ed., New Delhi, Wiley Eastern.
8. Kendall, M.G. and Stuart, A. (1979), *The Advanced Theory of Statistics*, Vol. II.

Stat PhD-702: Advanced Multivariate Analysis

4 Credits

Factor Analysis: Introduction, the orthogonal factor model, methods of estimation: *the principal component method, the principal factor solution. The maximum likelihood method, large sample test for the number of common factors,* factor rotation, factor scores: *the weighted least squares method, the regression method,* perspective and a strategy for factor analysis.

Cluster Analysis: Introduction, similarity measures: distances and similarity coefficients for pairs of items, similarities and association measures for pairs of variables, hierarchical clustering methods: *Single linkage, Complete linkage, average linkage, Ward's hierarchical clustering method.* nonhierarchical clustering methods: *K-means method,* clamping technique or Fuzzy clustering and partitioning methods.

Multidimensional Sealing: Introduction, statistics and terms associated with MDS, conducting MDS: *formulate*

the problem, obtain input data select an MDS procedure, decide on the number of dimensions, assessing reliability and validity, assumptions and limitations, relationship between MDS and factor analysis.

Correspondence Analysis: Introduction, statistics and terms associated with correspondence analysis, algebraic development of correspondence analysis, conducting a correspondence analysis: *formulate the problem, obtain input data, calculate row and column profile, and calculate row and column overviews, analysis summary output.*

Conjoint Analysis: Introduction, Conducting conjoint analysis: *Formulate the problem, construct the stimuli, decide on the form of input data, select a conjoint analysis procedure, assessing reliability and validity,* assumptions and limitations.

Structural Equation Modeling: Introduction, Statistics associated with SEM, foundations of SEM: *theory, model, path diagram, exogenous versus endogenous construct, dependence and correlation relationships, model fit, model identification,* conducting SEM, define the individual constructs, specify the measurement model, assessing measurement model reliability and validity, specify the structural model, assessing structural model validity, relationship of SEM to other multivariate technique, application of SEM: first-order factor model, second-order factor model.

Path Analysis

References:

1. Anderson,T.W.-An introduction to Multivariate statistical analysis, John Wiley.
2. Kirsagar, A.M.- Multivariate Analysis, Marcel Dekkar.

3. Morrison, D.S.- Multivariate Statistical Methods, McGraw-Hill.
4. Rao, C.R.- Linear Statistical Inference & its Applications, John Wiley.
5. Roy, S.N.-Some Aspects of Multivariate Analysis, John Wiley,.
6. Kendall,M.G.& Stuart, A- The Advanced Theory of Statistics, Vol-1 & 2, Charles Griffin.
7. Khatri, C.G. & Srivastava- Theory of Multivariate Analysis/
8. Tokenchi, K. Yanai, h. & Mukherjee, B- Foundations of Multivariate Analysis, Wiley.
9. Harris, R.J.- A Primer of Multivariate Statistics, Academic Press.
10. Tyron and Bailey- Cluster Analysis, McGraw- Hill.
11. Lawley and Maxwel- Factor Analysis as a Statistical method, Butterworth, London.
12. Bennett spencer & David Bowers- An Introduction to Multivariate techniques for Social & Behavioral Sciences, John Wiley & Sons, N.Y.
13. Cohen Jacob and P. Cohen Applied Multiple Regression/Correlation Analysis for the Behavioral science, John Wiley & Sons, N.Y.

Stat PhD-703: Advanced Robust Methods

4 Credits

Definition and aims of robust statistics, classical versus robust approaches to statistics; robust location and dispersion estimates, M-estimates of location with known scale, M-estimates of scale, simultaneous M-estimates of location and scale, numerical computation of M-estimates.

Measuring robustness – influence function, breakdown point, maximum asymptotic bias; balancing robustness and efficiency.

Correlation and regression – robust correlation estimates, linear regression models with fixed predictors: regression M-estimates; models with random predictors: MM-estimate, LMS estimate, S-estimate, LTS estimate, tau-estimate.

Robust confidence intervals and tests;

Optimal robustness: bias and variance optimality of location estimates, bias optimality of scale and dispersion estimates, the infinitesimal approach, the Hampel approach.

Estimates viewed as functional.

Multivariate analysis: breakdown and efficiency of multivariate estimates, multivariate M-estimates, estimates based on a robust scale - MVE estimate, S-estimate, MCD estimate; Stahel-Denoho estimate, fast robust estimates for dispersion matrix.

Robust principal components: robust PCA based on a robust scale, spherical principal components;

Robust linear model building: robust AIC, C_p and FPE criteria, robust step-by-step algorithms.

Robust estimates for the generalized linear models.

Text:

1. Maronna, R.A., Martin R. D., and Yohai, V. J. (2006), *Robust Statistics: Theory and Methods*, John Wiley & Sons.

References:

1. Hampel, F.R., Ronchetti, E.M., Rousseeuw, P.J., and Stahel, W.A. (1986), *Robust Statistics: The Approach Based on Influence Functions*, John Wiley & Sons.
2. Huber, P.J. (1981), *Robust Statistics*, John Wiley & Sons.

Stat PhD-704: Advanced Econometrics

4 Credits

Review of panel data regression models limited dependent variable model, logit model, probit mode, tobit mode.

Methodology of Econometrics Research: Desirable properties of an econometric model, AIC, BIC and other criteria of model selection.

Application of multivariate analysis to economic data, Discriminatory analysis, Principal components, Canonical correlation, Models of economic growth: Requirement of steady growth, the Harrod model, the Neo-classical model, Some applications to development economics, DOMR's growth model, Suitability of the models for underdeveloped countries, Mahalanobis model.

ARCH models, Co-integration, Unit roots analysis of panel data.

Econometric Modeling: The traditional view on econometric modeling, Leamer's and Hendry's approaches to model selection, Testing of non nested hypotheses.

Dynamic Econometric Model: Lagged variables, Autoregressive and distributed lag-models, Koyck approach to distributed lag-model.

Estimating the Parameters of a Set of Error Related Economic Relations: A seemingly unrelated regressions (SUR) model and its estimation, Combining time-series and cross-sectional data.

Time Series Econometrics: Stationary, Unit root tests, Spurious regression, Cointegration and error correction mechanism, Vector autoregressive (VAR) models, estimation of VAR models, Vector error correction model, Granger causality, Box-Jenkins methodology.

Advanced forecasting models: Regression with ARIMA error, intervention analysis, and multivariate autoregressive models.

Nonlinear Least Squares: Nonlinear models, Principles of nonlinear least squares estimation, Properties of the Nonlinear least squares estimator.

References

1. Johnston, J. (1984): *Econometric Methods*, 3rd edition, McGraw-Hill.
2. Jutge, G. G., Hill, R. C., Griffins, W. E., Lut Kepohl, H. and Lee, T C. (1988): Introduction to the Theory and Practical of Econometrics 2nd edition, John Wiley and sons, New York.
3. Greene, W. H. (2003): Econometric Analysis, 5th edition, Person.
4. Koustosiannis, A. (1986): *Theory of Econometrics,* 2nd edition, Macmillan.
5. Singh, S. P. (1977): *Econometrics and Mathematical Economics*, S. Chand Delhi.
6. Gujarati, D. (2003): Basic Econometrics, 4th edition, Mc education, India, Graw-Hill, New York.
7. Greene, W. H. (2000): *Econometric Analysis*, 4th edition, Prentice-Hall, India.
8. Griffiths, W.E. et al: *Learning and Practicing Econometrics*, John Wiley & Sons, Inc., New York.
9. Enders, W.: *Applied Econometric Time Series*, John Wiley & Sons, Inc., New York.

Stat PhD-705: Advanced Demography & Population Studies **4 Credits**

Population Policy and Population control Program in Bangladesh. Discussion of different methods of contraception and their use effectiveness, Measuring the

number of births averted by various methods of contraception, Measuring the impact of Family Planning Program in Fertility.

Techniques of Population analysis direct and indirect standardisation, decomposion Coal's indices of fertility, model fertility patterns.

Population Projections Including migration, methods of projections of fertility and mortality, projections of work force, school population and married women. Stochastic models for population growth and projections.

Model life table systems, United Nations set, Coale and Demeny regional tables, Brass General and Africa_Asian tables, the logit system, observed pattern of mortality in various countries, evaluation of model life table system. Multiple-decrement and increment-decrement Life tables.

Measurement of mortality, direct measurement from retrospective questioning inter-censal survival estimates, Childhood survival estimates based on orphanhood and widowhood.

Single life functions: Force of mortality, estimation of force of mortality from mortality table. Approximation to force of mortality, comparison of probabilities of dying and force of mortality.

Multiple-decrement Functions: Probabilities of decrement, central rates of decrement, Forces of decrement, Relationship between single decrement functions of multiple decrement table. Net nuptiality tables, Tables on multiple causes of death.

Application of Relational Gompertz Model in the estimation of Fertility. Application of Reduced Gompertz Model for estimating cohort fertility. Estimation of Fertility from synthetic cohorts.

Techniques for correcting age distribution for heaping on multiples of five graduation of age distribution.
Preparation of Research Proposal/Scheme Data Processing and use of Computer.

References:

1. W. Brass- The demography of Tropical Africa, Princeton University Press,1968.
2. W.Brass- Methods of estimating Fertility & Mortality from Defective and Limited data, University on North Carolina at Chapel Hill, 1967.
3. U.N.O- Methods of estimating demographic parameters from incomplete Data. Manual IV, 1967.
4. U.N.O- The determinants of consequence of population trends.
5. U.N.O- A manual of Measuring Migration.
6. U.N.O- Methods of Appraisal of Quality of Basic EData for. Population Estimate N.Y, Deptt. of Economic & Social Affarirs, 1955, Population studies No.23 Manual No. 11.
7. Ronald Pressat- Demographic Analysis.
8. National Academy of Science- Estimation of recent trends in Fertility & Mortality in Bangladesh.
9. C. Chandra Sekaron & A.F. Hermalin-Measuring the Effect of Development Centre of the OECD, 1975.
10. A.J. Coal & P.Demeny- Reginoal Model life tables & Stable Population, New Jersey, Princeton University Press, 1966.
11. H.S. Shryock & Others- The methods and Materials of Demography, Vol-1, Vol-2, U.S. Deptt. of Commerce- Bureau of the Census, 1971.
12. N.Keyfitz- Introduction to the Mathematics of Population, Addison- Wesley Publishing Co. 1968.

13. N.Meyfitz-Applied Mathematical Statistics.
14. Population of Bangladesh, UNO.
15. U.N. Manual X.
16. N.Keyfitz (1977)- Applied Mathematical Demography, Wiley.
17. C.L.Chiang (1984)- The Life table and its Applications, R.E. Krieger Publishing Co.

Stat PhD-706: Advanced Design of Experiments

4 Credits

Advanced Factorial Experiments: Description and construction methods of symmetrical and asymmetrical factorial experiments. Comparative study on the methods of construction. Methods of data analysis in factorial experiment. Illustration with practical examples. Comparative study on the methods of data analysis in factorial experiment. Confounding in factorial experiment. Methods of data analysis in factorial experiment with one or more factorial effects confounded. Illustration with practical examples. Detection methods of confounded effects in factorial experiment.

Non-orthogonal Designs: Split-split-plot deigns, Split-block designs, higher order Nested Designs, Designs for Bio-assays.

Incomplete Block Designs: Finite field, galoies field, etc. Construction of Incomplete block designs by different ways, resolvable and connected designs Combined estimates, Generally balanced designs, reinforced complete block design. Partially balanced incomplete block designs, lattice designs.

Response Surface designs: First order and second order designs, Central Composite designs, Orthogonal

blocking, cononical form, Steepest as cent, Rotatable designs, etc.

Optimal designs: Concept of normalised designs, Continuous designs, Properties of moment space. Some optimality criterial and their interpertation. Equivalence theorem. Some extensions.

References:

1. Das, M.N. and Giri, N.C.- Design and Analysis of Experiments, Wiley Eastern.
2. Kempthorme, C.- Design & Analysis of Experiments, Wiley.
3. Feferer, W.T.- Experimental Design: Theory and Applications.
4. Goulden, G.M.-Methods of Statistical Analysis.
5. John, P.W.M.- Statistical Design and Analysis of Experiments, McMillan.
6. Srivastava(Ed.)- A Survey of Statistical Design and Linear Models, North Holland.
7. Montgomery, D.C.- Design and Analysis of Experiments, Wiley.
8. Cochran, W.G. & Cox, G.M.- Experimental Design, Wiley.
9. Raghavarao, D. – Constructions & Combinational Problems in Deign of Experiments.
10. Federov, V.V.-Optimal Deign.
11. Silvey,S.D.- Optimal Design.
12. Myers- Response survface Methodology, Allyn & Cacon.

Stat PhD-707: Advanced Biostatistics 4 Credits

Survival Analysis: Survival data, Probability density, hazard and survival functions; Lifetime or failure time distribution; Parametric Procedure: Estimation and tests

for large and small samples; Non-parametric methods: Estimations of survival and hazard functions; comparison of survival curves; Parametric and semi-parametric regression model: Accelerated failure time and proportional hazard models, Goodness of fit tests; Multiple modes of failure.

Generalized Linear Model (GLM): Exponential family and GLM; Estimation and inference; Nominal and ordinal logistic regression; Poisson regression and log-liners models; GLM for longitudinal data: Binary and Count Data: Random effect models: Binary and Count Data.

Transition Model: Fitting models; Models for categorical and count data.

Text:

1. Lawless, J.F. 2003. Statistics Models and Methods for Lifetime Data. Wiley, New York.
2. Dobson, A.J. and Barnett, A.G. 2008. An Introduction to Generalized Linear Models. Chapman and Hall.
3. Diggle, P, Heagerty, P, Liang, K,Y, and Zeger, S, 2002. Analysis of Longitudinal Data. Oxford University Press, New York.

Stat PhD-708: Advanced Sampling Theory

4 Credits

Preliminaries: Advanced Topics in Stratified random sampling, Multivariate ratio and regression estimates, Problem of Stratifications, Post Stratification, Techniques of sample size determinations, design weights, etc.

Multi-Stage Sampling with unequal clusters: Selection of clusters with equal and unequal

probabilities with and without replacement. Estimates of different types, Standared errors. Self-weighting techniques in multistage designs: Different methods, self-weighting simple estimates, ratio & proportion estimation of standard error, stratified multi-stage sampling.

Non-Linear estimation of standard errors: Methods of Woddruff, Taylors Series expansion, Jackknife, Short cuts Applications.

Cost Functions: Cost Function and optimum allocation in multi-stage sampling, double sampling, sub-sampling faction.

Repeated sampling: Repeated sampling from same population sampling on two or more occasions. Estimates and standard errors.

Reliability & Validity: Survey data-their reliability & validity. Reliability measures sources of non-validation of data and their remedies, Tabulation plan and plan of analysis.

Applications: Familiarity with large-scale sample surveys in Bangladesh, Their defects & consequences, ways & means of overcoming such methodologies defects in national surveys. Estimates and their standard errors in national surveys, use of computer in analysis of data, report-writing.

References:

1. Cochran, W.G.- Sampling Techniques, Wily.
2. Raj, D.- Sampling theory, McGraw –Hill.
3. Raj, D- Sampling Design, McGraw- Hill.
4. Hansen, Hurwitz & Medow- Sample Survey Methods and Theory, Vols-1 & 2, Wiley.
5. Konjin, H.S.- Statistical Theory of Sample Survey Designs and Analysis, North-Holland.
6. Jessen, R.J- Sampling Methods, Wiley.

7. Johnon & Smith- New Developments in Survey Sampling, Wiley.
8. Kish, L.- Survey Sampling, Wiley.
9. Srivastava (ED)-A Survey of Statistical Designs and Linear Models, North-Holland.
10. Frankel- Inference from Survey Samples, Institute for Social Research, University of Michigan, USA.
11. Hocking, et al, - Contributions to Survey Sampling and Applied Statistics, Academic Press.

Stat PhD-709: Advanced Analysis of Planned Experiments **4 Credits**

Preliminaries: Generalized inverses of matrices, their existence, uniqueness and properties, methods of finding g-inverses, classes of g-inverse, their properties of such unique g-inverses, uses of g-inverses in solving system of equations.

Linear models of full rank and less than full rank, estimability andr reparametrization, Different version of Grass-markov theorem, Unified theory of least squares, Testable hypotheses, Non- testable hypotheses, checking for testability. Different methods of estimation, Minque, Mivque, Restricted ML, etc..

Usual Analysis of Experiments: General Theorem relating tests of ANOVA, orthogonal models, fixed, random and mixed models for cross-classification & nested classification general rules for finding d.f. and expectation of mean squares, Estimation of variance component. Approximate F-test, Application to various designs, Analysis of residuals, Non-orthogonal models; Two and higher way Non-orthogonal layouts, estimation and analysis.

Advanced Analysis of Experiments: Problems of Violation of ANOVA assumptions, WANOVA, HANOVA, MANOVA, Their definations, Importance and application, general theorem relating test of WANOVA, problems of ANOVA & WANOVA in Heteroscedastic models, Different approaches towards HANOVA-Adjusted Approach, Exact Approach, ASD Approach, ADF Approach etc. Recent developments in WANOVA, HANOVA MANOVA, etc.

Analysis of Group of Experiment : Introduction, Problems of analysis in such experiments, analysis of such experiments in different layouts both in homocedastic as well as heteroscedastic situations (including recent developments)

Analysis of Intercropping Experiments : Introduction, Problem in analysis of intercropping experiments: Different elements of such analysis: Recent developments in such experiments.

References:

1. Searle , S.R (1971), Linear Models, John Wiley.
2. Rao, C.R. & Mitra.- Generalized Inverses of Matrices and their applications .
3. Rao, C.R. Linear Statistical Inference and its Applications, Wiley Eastern.
4. Graybill.- F-An Introduction to linear Statistical models, Vo-1 & 2.
5. Cochran, W.G & Cox, G.M.- Experimental Design, Wiley.
6. Fisher, R.A.- Analysis of Planned Experiments.
7. Montogomery , D.C.- Design and Analysis of Experiments, Wiley.
8. John, P.W.M.- Statistical Designs and Analysis of experiment, McMillan.

9. Federer, W.T- Experimental Designs: Theory and Applications.
10. Khatri, C.G and Srivastava – Theory of Multivariate Analysis.
11. Sen, K- Some Contributions to Heteroscedastic Analysis of Variances (HANOVA). (Ph.D. Thesis-1984).
12. Talukder, M.A.H- Analysis of Variance with Unequal Error Variances (Ph.D- Thesis, 1976).
13. Bhuyan , K.C- Analysis of Groups of Experiments (Ph.D Thesis 1982.).
14. Mia. A.S.- Comparative Analysis of Groups of Experiment (Ph.D Thesis – 1991).
15. Rohim K.- A Study on Statistical Analysis of Data From Intercroping Experiments (Ph.D Thesis – 1988).
16. Seber- Linear Regression Analysis, Wiley.

Stat PhD-710: Advanced Statistical Meta-Analysis

4 Credits

Preliminaries: Meta-analysis, its development and uses, evidence-based health care, systematic reviews, why meta-analysis? Outcomes variables and effect size, binary, continuous, ordinal outcome measures.

Issues of meta-analysis: Assessing study heterogeneity, test of heterogeneity, possible causes of heterogeneity, methods for investigating and dealing with heterogeneity, validity of pooling studies with heterogeneity. Quasi-empirical Bayes methods.

Fixed effects methods for combining studies: Inverse variance weighted method, specific methods for combining odds ratios: Mantel-Haenszel method, Peto's method, exact methods for interval estimation.

Random effects model: Algebraic derivation, restricted maximum likelihood estimates, comparison of estimation methods, extensions to the random effects model. Subgroup analysis, meta-regression models, mixed effects models, extension of mixed modeling.

Publication bias: evidence and consequences of publication bias, identifying publication bias, funnel plot, adjusting the publication bias.

Study quality: Methodological factors affecting the study quality, incorporating study quality in meta-analysis, Quality effects model. Sensitivity analysis, sensitivity of results to meta-analytic methods.

Reporting the results of a meta-analysis: Overview and structure of a report, graphical displays used for reporting, data collection and quality, PRISM, CONSORT.

Bayesian methods in meta-analysis: Bayesian methods in health research, Bayesian meta-analysis of normally distributed and binary data, Empirical Bayes methods in meta-analysis. Missing data, Bayesian methods of missing data.

Meta-analysis of different types of data: Meta-analysis of individual patient data (IPD). Vote counting methods, combining p-values. Meta-analysis of multiple and correlated outcome measures. Meta-analysis of epidemiological and other observational studies. Meta-analysis of survival data. Meta-analysis of latent continuous data.

Meta analysis of gene expression data, MESH.

Software: rmeta, meta, etc. packages in R, comprehensive meta-analysis.

Text:

1. Sutton, A. J., Abrams, K. R., Jones, D. R., Sheldon, T. A., Song, F. (2000), *Methods for Meta-Analysis*

in Medical Research, John Wiley & Sons Ltd, West Sussex PO19 1UD, England.

References:

1. Borenstein, M., Hedges, L. V. (2009), *Introduction to meta-analysis*, John Wiley & Sons, Ltd.
2. Hedges, L. V., and Olkin, I. (1985), *Statistical Methods for Meta-Analysis*, John Wiley & Sons, Inc.
3. Hartung, J., Knapp, G., Sinha, B. S. (2008), *Statistical Meta-Analysis with Applications,* John Wiley & Sons, Inc.
4. Kulinskaya, E., Morgenthaler, S., Staudte, R. G. (2008), *Meta Analysis: A Guide to Calibrating and Combining Statistical Evidence,* John Wiley & Sons, Ltd.
5. Cochrane Handbook for Systematic Reviews of Interventions, *http://www.cochrane.org/training/cochrane-handbook.*

Stat PhD-711: Asymptotic Methods in Statistical Inference **4 Credits**

Convergence concepts, Slutsky's theorem and its consequences, Berry-Esseen Theorem, Edgeworth expansions, Delta method, Liapounov's Theorem, Introduction to asymptotic testing theory, power, sample size, efficiency, Relative efficiency, Robustness of test level, Confidence intervals, Point estimation, Asymptotic relative efficiency, Comparing estimators, Biased estimation, Pitman closeness, Random vectors, multivariate normality, Multivariate applications, Expectation functional, U-and V-statistics, Asymptotic normality of U-statistics, Influence function analysis, Bootstrapping, Maximum likelihood: regularity and

consistency, Fisher information, information inequality and consistency, Fisher information, information inequality, Asymptotics of likelihood estimation, multiparameter estimation, method of moments, Likelihood ratio, Wald's and Scores tests, Higher order asymptotics.

Required text:

1. Elements of Large-Sample Theory, E.L. Lehmann.

Supplementary text:

1. Advanced Calculus with Applications in Statistics, Andre I. Khuri.
2. Statistical Inference, George Casella and Roger L. Berger.
3. Introduction to the theory of statistics, A. Mood, F. Grabill, D. Boes.

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