54. MASTERS OF SCIENCE IN APPLIED STATISTICS

1. INTRODUCTION

This program gives graduates the knowledge and experience to tackle problems of statistical design, analysis and control likely to be encountered in business, industry or academia. The program is designed to acquaint students with the theory underlying modern statistical methods, to provide breadth in diverse areas of statistics and to give students practical experience through extensive application of statistical theory to real problems.

Through the selection of elective courses, the student may choose a program with an industrial emphasis or one with a more theoretical emphasis.

The applied statistics program will offer an integrated interdisciplinary curriculum combining statistics, computer science, and communication skills. The applied statistics two year Master's Program will be based upon a core curriculum and train students by having them participate in projects with practical deliverables. The program will place special emphasis on applications in science, engineering, and business. Projects are selected by an applied statistics course advisory board. The graduate will have studied not only the standard mathematical and statistical tools, but also the basic ideas of engineering and business, and will have received training in project development and in modes of industrial communication.

2. RATIONALE FOR THE PROGRAM

The importance of computer science in science, engineering, and business requires no justification. On the other hand, the role of mathematics is arguably as important, but not nearly as well understood or appreciated. Broadly speaking as the complexity, difficulty, size, or structure of a problem grows, mathematical analysis assumes increasing importance. An interdisciplinary program combining mathematics and information sciences is an research area that is critical to science and technology and in which BUC can build a research program of national significance.

Our two year applied statistics Master's Program will be structured so that graduates will have developed three overlapping skill sets:

1) their knowledge of *mathematics* will allow them to contribute to the solutions of complex problems requiring sophisticated analysis;

2) their knowledge of *computer science* will allow them to develop algorithms and software so that the solutions can be realized in practice; and

3) their facility with oral and written *communication skills* and project management will allow them to insert new technology into an organization. For this reason, our program will be interdisciplinary and place equal emphasis on statistics, mathematics, information sciences, oral and written communication skills, and project management.

Our approach is to focus on core courses together with a project-oriented curriculum so that the students leaving the two year Master's Program will have worked as a team member on one or more projects with practical deliverables. We expect that the majority of Master's students will take jobs in industry and that this particular combination of disciplines combined with a practical project orientation will provide them with a significant advantage when looking for jobs. We use an applied statistics advisory board to ensure that the projects we select and the students we graduate are of interest to industry.

3. EMPLOYMENT OPPORTUNITIES:

Opportunities include systems statistician , analyst ,research associate, and technical consultant. Employment areas include state governments, private sector, financial industry, as well as banks, and industrial companies.

4. OBJECTIVES:

The main objectives of this programme are to:

(a) Equip the student with a broad based statistical knowledge and skills.

(b) Train statisticians for employment in both Public and Private Sectors.

(c) Prepare candidates for postgraduate studies and research in statistics.

The specific objectives of this programme are to:

(a) Produce generalized problem solvers of great versatility, capable of moving within an organization from task to task.

(b) Prepare graduates who will have studied not only the standard mathematical and statistical tools, but also the basic ideas of engineering and business,

(c) survey mathematics of particular importance to industry

(d) gain experience in team project report generation

(e) produce generalized problem solvers of great versatility, capable of moving within an organization from task to task.

5. ADMISSION REQUIREMENTS

A bachelor's degree is required for admission to Master of Science in Applied Statistics Program. A basic knowledge of undergraduate analysis, linear algebra and differential equations is assumed for applicants to the master's programs in Applied Statistics. A strong background in mathematics, which should include courses in undergraduate analysis and linear algebra, is assumed for applicants to the master's program in Applied Statistics. Typically, an entering student in the master of science in applied statistics program will have an undergraduate major in the mathematical sciences, engineering or a physical science; however, individuals with other backgrounds will be considered. In any case, an applicant will need a strong background in mathematics, which should include courses in undergraduate analysis and probability. Students with serious deficiencies may be required to correct them on a noncredit basis.

6. EXAMINATIONS

(a) The university college and school of mathematics and actuarial sciences common examination regulations shall apply,

(b) Examinations shall be held at the end of the semester in which the courses are taught,

7. EVALUATION

7.1 COURSEWORK AND EXAMINATION

(a) Each course shall be examined by a 3-hour end of semester written examination. This will account for 60% of the total mark in each course.

(b) Each course shall be examined by continuous coursework assessment comprising seminar papers, projects, reports, formal tests and participation in learning activities. This will account for 40% of the total mark in each course.

(c) The pass mark in each course (continuous assessment and written examination) shall be 50%.

(d) A candidate who fails in more than two courses shall be discontinued.

(e) A candidate who fails less in less than two course shall sit for a supplementary examination.

(f) Each supplementary examination shall be awarded a maximum of 50%.

(g) A candidate who fails any paper taken as a supplementary examination shall be discontinued.

(h) Grades obtained in an extra or optional course shall be reflected in the transcripts.

(i) A student who fails an extra or optional course shall not be penalized as long as he/she has the minimum prescribed course units.

(j) Under exceptional circumstances, such as medical or compassionate grounds, supported by authentic written evidence, examinations may be held for the candidate.

A special examination shall be treated as a regular written examination.

7.2 THESIS WRITING

The master's thesis is an original piece of statistical research work which focuses on advancing the state of the statistical art. The master's project consists of a creative application of statistics to a real-world problem. It focuses on problem definition and solution using statistical and mathematical tools. The master's practicum requires a student to demonstrate the integration of advanced statistical concepts and methods into professional practice. This could be done through a industrial internship in industry or an applied research laboratory.

(a) A student shall, during the degree programme, write a thesis on a specific topic in Mathematics.

(b) Thesis supervisor(s) shall be appointed for the students at the start of the second semester, through the active involvement of the student.

Where departmental rules are silent the common regulations for submission and examination of the School of Graduate Studies, (SGS) shall apply.

7.3 GRADING SYSTEM

Percentage	Grade	Remarks
75 – 100	A	Distinction
65 – 74	B	Credit
50 – 64	C	Pass
Below 50	E	Fail

8. LEARNING AND TEACHING METHODS

A problem solving approach shall be used with emphasis on library research, open problems, project, modeling and seminar.

9. DURATION OF THE PROGRAMME

The degree will typically require 2 years and a maximum of four (4) years.

to complete - 5 courses per semester for 2 semesters. Support is occasionally available by serving as a Graduate Assistant for the department of pure and applied Mathematics.

10. COURSE STRUCTURE

COURSE REQUIREMENTS

Each student in this program is required to take at least 8 (eight) courses at 5800 level as well as undertaking an approved Thesis research on a topic of interest. The 800 courses consist of the following six core courses: WAS 5801, WAS 5803, WAS 5805, WAS 5811, WAS 5872 and WAS 5814 as well as two courses from the areas of specialization (Mathematical statistics, Biometrics, Time series and Stochastic processes, Biostatistics, Statistical Modeling).

COURSE CONTENTS

FIRST YEAR		
SEMESTER I	**(All Core Courses)**	**Units**
WAS 5801	Experimental Design I	4
WAS 5803	Theory of Linear Models	4
WAS 5805	Multivariate Analysis	4
SEMESTER II		
WAS 5814	Statistical Inference I	4
WAS 5872	Statistical Computing I	4
WAS 5891	Research Methodology	4
Elective(s) courses (Choose any one group)		
1. Biometry		
WAS 5802	Experimental Design II	4
WAS 5807	Sampling Theory and Practice I	4
2. Mathematical Statistics		
WAS 5816	Large Sample Theory of Statistical Inference	4
WAS 5831	Theory of Nonparametric Statistics I	4
3. Time Series and Stochastic Processes		
WAS 5841:	Time Series I	4
WAS 5843:	Applied Nonlinear Regression	4

4. Biostatistics		
WAS 5851	Categorical Data Analysis	4
WAS 5852	Statistical Methods for Biostatistics and Epidemiology	4
5. Statistical Consulting, Computing and Modelling		
WAS 5871	Statistical Consulting	4
WAS 5873	Statistical Model Building and Learning	4
SECOND YEAR		
SEMESTER 1 (Core Courses)		
WAS 5892:	Proposal Writing	4
Electives: (Any one group)		
1.Biometry		
WAS 5861	Statistical Methods for Spatial Data	4
WAS 5862	Environmental Statistics	4
2. Mathematical Statistics		
WAS 5833	Bootstrapping Techniques	4
WAS 5835	Bayesian Inference	4
WAS 5836	Statistical Decision Theory	4
3. Time Series and Stochastic Processes		
WAS 5844	Stochastic Processes I	4
4. Biostatistics		
WAS 5853	Survival Analysis Theory and Methods	4
5. Statistical Consulting, Computing and Modeling		
WAS 5875	Mathematical Models in Finance	4
WAS 5876	Statistical Methods for Process Improvement	4
SEMESTER II		
WAS 5893	Thesis Writing	6
		42

CORE COURSES

WAS 5801 Experimental Design I

Review of experimental designs in a regression setting; analysis of variance; replication, balance, blocking, randomization and randomization model, interaction and strata for randomized experiments; one-way layout, two-way layout, and Latin square as special cases; factorial structure of treatments; covariates; treatment contrasts; two-level fractional factorial designs; fixed versus random effects; split plot and repeated measures designs; other topics.

WAS 5803 Theory of Linear Models

The Gauss-Markov model is introduced. Estimability, parameter estimation, analysis of variance, hypothesis testing, restricted models. Reparametarization, two-part model, correlated data, and fixed, mixed and random effects models. Least squares, distribution theory, F-tests from likelihood ratio, sums of squares distribution theory, generalized least squares, random and mixed Models, restricted likelihood estimation, generalized linear models.

WAS 5805 Multivariate Analysis

Relevant matrix theory, multivariate problems as extensions of univariate problems, multivariate random vectors, exact and asymptotic distributions, multivariate normal distribution (MVN), Wishart distribution; distribution of partial and multiple correlation coefficients; Hotelling's T^2, Q-Q plots, sampling from MVN and inference for population mean vector, covariance matrix, correlation matrix, MANOVA, principal component analysis, factor analysis, discriminant analysis and classification and clustering.

WAS 5811 Theory of Probability I

Measurable spaces and measures, Lebesgue-Stieljes measure, independence, almost sure and in probability convergence, integration in probability spaces, product measures, absolute continuity of measures, weak law of large numbers, strong law of large number, weak convergence. Probability measures, random variables as measurable functions, expectation, independence, characteristic functions, limit theorems, applications.

WAS 5814 Statistical Inference I

Exponential families; more on sufficiency, completeness, ancilliarity, and UMVUE; C-R lower bound and Fisher information for single and multi parameter cases, equivariance; large sample theory; likelihood estimation and asymptotic efficiency. Theory of uniformly most powerful tests, unbiased tests, biased tests, and invariant tests, maximum tests, confidence tests, asymptotic theory for standard large sample likelihood based tests, theory of linear rank tests.

WAS 5872 Statistical computing I

Review of basic numerical methods. Numerical algorithms in statistics; optimization techniques; elements and statistical uses of Monte Carlo methods; EM algorithm; model search and model averaging, simulation of random variables, stochastic processes and stochastic models in finance. Numerical solution of deterministic and stochastic differential equations. Valuation of complex financial instruments and derivative securities. Data visualization; dimension reduction, classification and discrimination, clustering algorithms.

AREAS OF SPECIALIZATION

1. BIOMETRY

WAS 5802 Experimental Design II

Two-level factorial and factorial designs, applications, blocking, polynomial models, first order response surface design, second order designs, several responses, determination of optimum conditions, canonical reduction, design criterial involving variance and bias. Baye's designs and discrimination designs. Pre:WAS 5801.

WAS 5807 Sampling Theory and Practice I

Sources of survey error. Probability sampling designs, estimation and efficiency comparisons. Distribution theory and confidence intervals. Generalized regression estimation. Software for survey and analysis.

WAS 5861 Statistical Methods for Spatial Data

Theoretical foundations of spatial statistics, models for spatial data and methods for model fitting, statistical inference, and spatial prediction. Detecting and quantifying spatial patterns and modeling in the presence of such patterns. Spatial point patterns: testing nonrandom ness, simulating and characterizing patterns. Lattice data: spatial auto correlation and regression. Geostatistics: variograms ordinary and universal kriging, inference, assessing assumptions, and extensions.

WAS 5862 Environmental Statistics

Methods of sampling the environment and subsequent analysis of resulting data are considered. Emphasis is placed on design-based analysis and spatial data analysis. Special topics include environmental variables, environmental toxicology and long-term trend detection.

2. MATHEMATICAL STATISTICS

WAS 5816 Large Sample Theory of Statistical Inference

Stochastic models of convergence. Asymptotic theory of normed sums of random variables with applications to asymptotic normality of estimators. Methods for deriving limit distribution of nonlinear statistics. Asymptotic relative efficiencies. Asymptotic confidence regions and tests of hypotheses. Models of non-identical distributed or dependent random variables. Pre WAS 5814.

WAS 5831 Theory of Nonparametric Statistics I

Nonparametric estimation and hypothesis testing, relative efficiency, exchangeable random variables, ranking and distribution free statistics, generalized U-Statistics, generalized linear rank statistics, limiting distributions of certain nonparametric statistics, density estimation and related topics.

WAS 5833 Bootstrapping Techniques

The jackknife and bvootstrap, bootstrap confidence intervals, prepivoting, asymptotic validity and invalidity, bootstrap accuracy and Edge worth expansions, bootstrap for

regression and auto-regression, bootstrapping Markov chain models, moving block bootstrap for general weakly dependent data. Pre:WAS 5831.

WAS 5835 Bayesian Inference

Sampling theory and its critique, subjective probability, likelihood principles, Bayes theorem, Bayesian analysis of Normal theory inference problems, the Behrens-Fisher problem assessment of model assumption, robustness of inference, analysis of variance, estimation of variance components, empirical Bayes, some aspects of multivariate problems.

WAS 5836 Statistical Decision Theory

Essential elements of decision theory, game theoretic approach, normal forms, extensive forms, zero sum games, minimax theorem, Bayesian Inference and decision rules, admissibility and minimaxity results, minimax estimation for normal Poisson means multiple decision problems, gamma-minimaxity. Sequential games, axiomatic treatment of utility, complete classes of decision functions and strategies. Estimation theory, hypothesis testing, power and regret functions, invariant test. Programming, dynamic programming form the decision point of view.

3. TIME SERIES AND STOCHASTIC PROCESSES

WAS 5841 Time Series I

Iterative model building. ARIMA models, application to forecasting, seasonal models, applications, multiple time series modeling including transfer function and intervention analysis. Various special topics in time series such as outliers, robustness, order determination methods, Kalman filtering, sampling and aggregation, seasonal adjustments.

WAS 5843 Applied Nonlinear Regression

Statistical modeling using nonlinear regression is considered. Topics include fixed-effects nonlinear regression models, nonlinear least squares, computational methods and practical matters, growth models, and compartmental models. Nonlinear mixed-effects models are

discussed, including model interpretation, estimation and inference. Examples will be drawn from forestry, pharmaceutical sciences, and other fields.

WAS 5844 Stochastic Processes I

Markov chains: classification, recurrence, transience, limit theory. Renewal theory, Markov processes, birth-death processes. Applications to queuing, branching and other models in science, engineering and business. Topics drawn from semi-Markov processes, martingales. Brownian motion.

4. BIOSTATISTICS

WAS 5851 Categorical data analysis

Chi-square tests and their theoretical basis. The likelihood ratio test, Two-way and multiway tables. Loglinearmodels, Bernoulli models.

STAT 852 Statistical Methods for Biostatistics and Epidemiology

Design of medical studies including cohort designs, case-control studies and clinical trials. Measures of association in epidemiological studies. Analysis of data fro cohort studies, clinical trials and case-control studies. Covers epidemiological study design measures of association, rates, classical contingency table methods, and logistic and poisson regression. Multiplicity in clinical trials, group randomized designs, sequential and group sequential procedures as time permits. Use of a statistical package (e.g. SAS or S-Plus) to analyze medical data.

WAS 5853 Survival Analysis Theory and Methods

Methods for comparing time-to-event data, analyzing data on the tie to failure with particular emphasis on the use of regression models for such data. Both parametric and semi-parametric regression models will be considered. The proportional hazards regression model, and a review of current topics in survival analysis.

5. STATISTICAL CONSULTING, COMPUTING AND MODELING

WAS 5871 Statistical Consulting

This course will cover some of the basic tools of a statistical consultant. Topics will include the use of statistical packages, problem-solving techniques, discussion of common statistical consulting problems, effective communication of statistical concepts and management of consulting sessions.

WAS 5873 Statistical Model Building and Learning

Theory of reproducing Kernel Hilbert spaces in statistical model building; bounded linear functionals and representer theory smoothing splines; Anova spines; degrees of freedom for signal and the bias-variance tradeoff; Bayesian confidence intervals; model selection. P:Stat 710 or cons inst.

STAT 875 Mathematical models in Finance

Mathematical techniques used to price and hedge derivative securities in modern finance. Modeling, analysis and computations for financial derivative products, including exotic options and swaps in all asset classes. Applications of derivatives practice

WAS 5876 Statistical Methods for Process Improvement

Statistical methods for improving processes based on observational data. Assessment of measurement systems. Strategies for variation reduction. Process monitoring, control adjustment. Clue generation techniques for determining the sources of variability. Variation transmission. Design techniques in process control.

WAS 5891 Research Methodology

Research Methodology. Open problems. New techniques in Statistics.

WAS 5892 Proposal Writing

Proposal writing

WAS 5893 Thesis

Thesis writing