Statistics Graduate Programs

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About Statistics

The statistics department faculty is known for both cutting edge methodological and collaborative research and for outstanding teaching. Faculty members are currently investigating statistical problems in the fields of ecology, genetics, economics, meteorology, wildlife management, epidemiology, AIDS research, geophysics, and climatology. The program's faculty members have ongoing collaborative programs across disciplines such as biostatistics, bioinformatics, economics, atmospheric science, psychology and with the Missouri Department of Conservation.

The graduate program provides opportunities for graduate study and thesis direction in various areas of probability and statistics, both theoretical and applied. A variety of consulting and collaborative opportunities allow both faculty and graduate students to conduct cooperative and interdisciplinary research. Regular statistics colloquia provide opportunities for faculty and outside speakers to present the results of their research. Faculty and graduate students also participate in weekly seminar series in Bayesian statistics, bioinformatics, and biostatistics.

Degrees Available

- MA and PhD in statistics
- MA in statistics with emphasis in biostatistics
- MA in statistics with emphasis in data analytics
- Dual MA in statistics and economics
- Graduate Minor in Statistics

Career Opportunities

Statisticians are in demand in education, medicine, government, business and industry as well as in the biological, social and physical sciences.

Facilities & Resources

The Department of Statistics maintains a state-of-the-art computer network with Linux workstations and servers for research and personal productivity software on PCs. Students have access to the network through PCs in student offices and through the statistics department computer laboratory. An extensive library of software including R, SAS, and common programming languages is maintained. Students also have access to the campus computing network. The statistics department is located in newly renovated space in Middlebush, with easy access to the main library's outstanding collection of books and journals in statistics.

Financial Aid from the Program

Fellowships and teaching and research assistantships are available to qualified graduate students. Some programs require an extra form or statement from those who wish to be considered for internal assistantships, fellowships or other funding packages. Check the program website or ask the program contact for details.

Statistics Faculty

Christopher K. Wikle
Chair, Curators' Distinguished Professor; PhD, Iowa State University.

Scott H. Holan
Professor; PhD, Texas A&M University.

Dongchu Sun
Professor; PhD, Purdue University

Jianguo Sun
Professor; PhD, University of Waterloo, Canada.

Chong Zhuoqiong He
Professor; PhD, Purdue University.

Sounak Chakraborty
Associate Professor; PhD, University of Florida.

Shih-Kang Chao
Assistant Professor; PhD, Humboldt University of Berlin, Germany

Tieming Ji
Assistant Professor; PhD, Iowa State University

Athanasios C. Micheas
Director of Graduate Studies, Associate Professor; PhD, University of Connecticut.

Erin Schliep
Director of Graduate Admissions, Assistant Professor; PhD, Colorado State University.

Kangwon Seo
Assistant Professor; PhD, Arizona State University (joint appointment with Industrial and Manufacturing Systems Engineering)

Lori Thombs
Director of the Social Science Statistics Center, Associate Professor; PhD, Southern Methodist University.

Lawrence Ries
Associate Chair, Associate Teaching Professor; PhD, University of Missouri.

Suhwon Lee
Associate Teaching Professor, Director of Undergraduate Studies; PhD, University of Missouri.

Isabella Zaniletti
Assistant Teaching Professor; PhD, University of Missouri.

Application and Admission Information

Admission Criteria

Fall deadline: January 15
Spring deadline: October 15

Minimum TOEFL scores:

Internet-based test (iBT)	Paper-based test (PBT)
80	550

- Minimum GPA: 3.0 in math and statistics courses to enter master's program; 3.5 in math and statistics to enter PhD program
- Bachelor's degree from accredited college or university in related area

Undergraduate courses in statistics are recommended but not required. Consideration also is given to rank in graduating class, trends in grade records, maturity and experience, and other criteria bearing on qualifications.

Before entering the graduate program, a student should have a background that includes three semesters of calculus (or equivalent), one semester of matrix theory, and at least one post-calculus course in probability and statistics. Some required courses at the 7000 level not taken as an undergraduate may be taken for graduate credit as part of the graduate program.

Required Application Materials

To the Graduate School:
All required Graduate School documents

To the Program:
Departmental application
3 letters of recommendation (use departmental form)
Letter of intent
GRE score report

Master of Arts in Statistics

Degree Requirements

The general requirements for receiving a master's degree are at least 30 semester hours of course work at the 7000 level or higher, of which at least 18 hours must be from the Department of Statistics at MU. The 30 hours may not include credit hours of 7020, 7050, 7150, 7210, 7510, 7530, 7560, 7710 or 8220 or more than a total of six hours of 8090. The 30 credit hours may not include 7000 level courses for which corresponding 4000 level courses where taken as an undergraduate student.

At least 15 semester hours of course work at the 8000 level or above must be taken from the Department of Statistics at MU. The 15 semester hours cannot include more than a total of three hours of 8090.

Additional courses recommended but not required are Statistics 7110, 7310, 7410, 7420, 7430, 7450, 7610, 7810, 7830, 7850, 7870, 8310, 8320, 8370, 8410, 8640, 9250, 9310, 9320, and 9410; Mathematics 7700 and 7900; Computer Science 1050 or 2050.

Remedial Courses

The following courses are required if equivalent courses were not taken as an undergraduate: Mathematics 7140, Statistics 7750 and 7760. These courses may not be used for more than six of the required 30 hours.

Applied Track Masters of Arts Degree

Required core courses

Students must complete the following six courses or equivalent.

Stat 7110	Statistical software and data analysis
Stat 7540	Experimental design
Stat 7750	Introduction to probability theory
Stat 7760	Statistical inference
Stat 8310	Data Analysis I
Stat 8320	Data Analysis II

In addition, students must take four elective courses, at least three of which must be selected from the department of statistics course offerings numbered 8000 or above.

Examination

Students in the Applied Track Master's program will satisfy their graduate school final examination requirement by successfully developing an independent project or portfolio to demonstrate their mastery of statistical methods, applications, and/or computation, or a report detailing the statistical aspects of an approved Statistics-based internship, as determined by the Director of Graduate Studies (or his/her designated representative). The project/portfolio will be supervised by a Department of Statistics graduate faculty member. This requirement can be satisfied by successful (B or better) completion of the Applied Masters Capstone (Stat 8???, TBA) course, if the course has sufficient enrollment to be offered.

The only exception to the project/portfolio requirement occurs when a student successfully passes both sections of the Department of Statistics Qualifying Exam. To be eligible to take this exam, students will be required to obtain approval from the Director of Graduate Studies and at least 3 recommendations from doctoral faculty of the Department of Statistics. Without exception, students are allowed a maximum of two attempts to pass the Qualifying Exam. Upon a second failure, the student may opt to complete a portfolio/project for the exam requirement. Note that passing this exam does not constitute acceptance into the Ph.D. program. However, note that if one is accepted into the Ph.D. program, these exam attempts count towards the maximum allowed per Ph.D. qualifying exam rules.

The Applied Masters Capstone course will be scheduled to run each Spring if there are the required minimum 6 students enrolled. Regular track (and Economics dual track) master's students would not be eligible to take the Applied Master's Capstone class.

Regular Track Masters of Arts Degree

A candidate for the regular master of arts degree, may choose either an exam or a thesis option in order to satisfy the main requirement for the Masters degree.

Exam Option

A candidate may choose to take the qualifying exam (the same exam as Ph.D. candidates, see Doctorate of Statistics requirements for more details) instead of writing a thesis and presenting it.

Thesis Option

Original Written Work

Under this option, all candidates must submit a written report on an independent effort toward producing original work. This report may, with the adviser's consent, take the form of a thesis, a written review on a set of papers in statistics, or a written report on an independent study project, which may include an original application of statistics. For this work, a student must register for at least three semester hours of 8090.

Presenting the Work

Under the thesis option, all candidates are required to present an open seminar on the results of the written report. The report should be made available for public review, through the Department of Statistics office, for at least one week before the examination.

Examination

Under the thesis option, the MA examination covers material presented in the written report and the seminar and may also cover course work.

Satisfactory Progress and Additional Requirements

Length of Study
A master's candidate is expected to complete the master's degree within three calendar years beginning with the first semester of enrollment unless approval is obtained from the graduate faculty of the Department of Statistics.

Grade Requirements

Any student, while a graduate student in this program, who receives a grade of F in a three hour course, or C or lower in six or more hours of courses offered by the Department of Statistics or a grade of C or lower in nine or more hours of all courses taken will be dismissed from the graduate program unless contrary action is taken by the graduate faculty of the department.

For each credit hour over three hours with a grade of C or lower in courses offered by the Department of Statistics at the 7000 level and above, the student must receive a credit hour with a grade of A in courses offered by the department at the 7000 level and above. Students must maintain a GPA of 3.0.

MA in Statistics with Emphasis in Biostatistics

Students who wish to specialize in biostatistics may obtain a degree with special emphasis. The general requirements are the same as those for the MA degree in statistics. In addition, students must satisfy the following.

(i) Take statistics 7410 and (ii) either 7420, 8410 or 9410 or the equivalent;

(ii) Submit a project or thesis related to biostatistics or take the qualifying examination (see Doctorate of Statistics requirements for more details).

MA in Statistics with Emphasis in Data Analytics

Students who wish to specialize in data analytics may obtain a degree with special emphasis. The general requirements are the same as those for the MA degree in statistics. In addition, students must satisfy the following.

(i) Required statistics courses: 7110, 7750, 7760, 8310, 8320, 8330, 8640 or equivalent;

(ii) Submit a project or thesis related to data analytics or take the qualifying examination (see Doctorate of Statistics requirements for more details).

Dual Master's Degree in Economics and Statistics

The department offers a cooperative MA degree with the Economics Department. Students may obtain MA degrees in economics and statistics with 48 hours of course work numbered 7000 or higher from the University of Missouri instead of the 52 or more required for separate degrees. (These 48 hours may not include any of the following: Economics 7351, 7353, or Statistics 7510, 7530, 7710.) Eighteen or more hours are required from the Department of Economics. At least 15 hours must be numbered 8000 or higher with no more than four hours of 8090. Students must take the core economics courses 8451 and 8453 and research workshop 8413 (3 credit hours). Eighteen or more hours are required from the Department of Statistics. At least 15 hours must be numbered 8000 or higher with no more than three hours of 8090. Statistics 7750 and 7760 and Mathematics 7140 are required if equivalent courses were not taken as an undergraduate.

All candidates must submit a thesis or written project demonstrating an independent effort towards producing original work satisfactory for each degree. The candidate may complete separate theses/projects for both economics and statistics or a single joint thesis/project satisfying both requirements. Alternatively, the candidate may satisfy the statistics degree requirement by taking the qualifying examination (see Doctorate of Statistics requirements for more details).

Master's Minor

To receive a designated minor in statistics for a master's degree, at least 12 credit hours of course work at the 7000 level or higher must be completed from the Department of Statistics at MU. The courses should be unified in theme and must be approved by the director of graduate studies in the Department of Statistics.

The courses must be completed with an average grade of B (3.0) or higher; shall not include Statistics 7002, 7070, 7085, 8085 or 9085; and shall not include more than one course from Statistics 7710 and 7750.

Doctorate in Statistics

A minimum of 72 hours are required. A student's doctoral program committee must approve all course work used to satisfy the credit-hour requirement and may require additional course work beyond these minimums. The doctoral committee may recommend that up to 30 hours of post-baccalaureate graduate credit from an accredited university be transferred toward the total hours required for the doctoral degree, subject to approval by the Graduate School.

The doctoral program has considerable flexibility. Each student's adviser and committee will determine a suitable course of study. However, all students must take the following courses or their equivalents at comparable institutions.

Statistics 8710 (Intermediate Mathematical Statistics I)
Statistics 8720 (Intermediate Mathematical Statistics II)
Statistics 8310 (Data Analysis I)
Statistics 8320 (Data Analysis II)
Statistics 9310 (Theory of Linear Models)
Statistics 9710 (Advanced Mathematical Statistics I)
Statistics 9720 (Advanced Mathematical Statistics II)

Qualifying Examination

Exam Parts

All doctoral students must pass the Qualifying Exam, which is offered in June (and August if someone fails in June) of each year. The exam consists of two parts, one covering Statistics 8710 and 8720, and a second part covering Statistics 8310 and 8320. All doctoral students must take the exams at the first opportunity after taking the required courses, typically in early June after the end of their second semester in the program. Students have two attempts to pass each part.

Exam Administration

The qualifying examination committee would consist of the Director of Graduate Studies (DGS), an Examination Committee Chairman and at least 4 additional committee members, including at least one representative who has taught 8310/8320 and one who has taught 8710/8720; the exact number is decided such that there are a minimum of two people on the committee writing questions for each part (8310/20 and 8710/20). Thus, the committee is responsible for writing all examination questions, but will

consult with others who have taught the class most recently to ensure proper coverage of the material.

The committee will be appointed by the Chair of the Department. With the exception of the DGS, all committee members will serve a maximum of two-year terms (with no member other than the DGS serving two consecutive terms). In cases where it is not possible to staff the committee with representatives of 8310/20 and 8710/8720, the faculty who have taught those classes will serve as consultants to the committee.

Doctoral Committee

Within one semester of passing the qualifying examination, a student must choose a doctoral program committee in consultation with his or her adviser. This committee shall consist of at least four members, at least three from the doctoral faculty in statistics and at least one from another MU doctoral program. The committee members from statistics must include at least two faculty in addition to the student's adviser(s), so students who are co-advised by two statistics faculty must have a total of at least five committee members.

Comprehensive Exam:

Following the graduate school rules, the comprehensive examination is the most advanced posed by MU. It consists of written and oral sections. It must be completed at least seven months before the final defense of the dissertation. The two sections of the examination must be completed within one month. The student must be enrolled to take this examination. It is to be administered only when MU is officially in session.

The written portion of the exam will be arranged and supervised by the student's major advisor(s). The exam will be given up to one year after the student has completed the required Ph.D. courses. Questions are prepared by each of the student's committee members (doctoral advisory committee). The comprehensive exam is NOT to be used as a dissertation proposal.

For the comprehensive examination to be completed successfully, the doctoral advisory committee must vote to pass the student on the entire examination, both written and oral sections, with no more than one dissenting or abstaining vote.

A failure of either the written or oral section of the exam constitutes failure of the comprehensive exam. If a failure is reported, the committee also must include in the report an outline of the general weaknesses or deficiencies of the student's work. The student and the committee members are encouraged to work together to identify steps the student might take to become fully prepared for the next examination.

A student who fails may not take a second comprehensive examination for at least 12 weeks. Failure to pass two comprehensive examinations automatically prevents candidacy.

Additional Required Course Work

Before taking the comprehensive examination, students should complete six courses from the following: Statistics 9100, 9250, 9320, 9370, 9410, 9510, 9530, 9640, 9810 and 9820 taken at MU or at comparable institutions OR five courses from this list in addition to BOTH Statistics 8330 and 8640. (Different 9100s can be counted more than once). Other 9000-level courses may be substituted at the discretion of the student's doctoral program committee.

Dissertation

A dissertation, prepared under the direction of a dissertation supervisor, is required. The dissertation should be presented in an open seminar as part of the final examination, which is be conducted by the final examination committee. The dissertation should be made available for public review, through the Department of Statistics office, for at least one week before the examination. Dissertation proposal: The student's major advisor(s) is required to convene the doctoral advisory committee at least 5 months before the dissertation defense date, and more than 2 months after the successful completion of the comprehensive examination, in order to

review the dissertation proposal and progress of the Ph.D. candidate as he/she prepares for their thesis defense. The candidate shall present the current status of his/her thesis and solicit input and feedback from the committee members.

Additional Requirements

Additional requirements for the PhD in statistics are determined by the student's program committee and the director of graduate studies.

Ph.D. Timeline Summary

The process and timeline for a successful Ph.D. candidacy can be summarized as follows:

Qualifying Examination:
After the first year in the department, and having completed STAT 8710, STAT 8720, STAT 8310 and STAT 8320, the candidate must take the qualifying examination (typically administered in the beginning of June). Should the candidate fail, they have to take the exam again, a few days before the next semester begins (typically in early August). The candidate may now choose their advisor (if they do not have one already).

Comprehensive Examination:
This examination must take place up to one year after the student has completed the required Ph.D. courses (see the section on required courses).

Dissertation proposal:
The student's major advisor(s) is required to convene the doctoral advisory committee at least 5 months before the dissertation defense date, and after the successful completion of the comprehensive examination.

Thesis Defense:
This is the final examination for the Ph.D. candidate. It has to be given at least 5 months after the dissertation proposal. Note that graduate school rules require at least 7 months between the comprehensive examination and the thesis defense.

PhD Minor

To receive a designated minor in statistics for a PhD degree, at least 15 credit hours of course work at the 7000 level or higher must be completed from the Department of Statistics at MU. The courses must include at least two at the 8000 level or higher and may not include Statistics 7002, 7020, 7050, 7070, 7085, 7530, 8085, 8090, or 9085. Students must have at least one course in calculus-based statistics and the equivalent of at least two courses in an applied statistics sequence. The calculus-based statistics requirement can be met by Stat 7710 or Stat 7760, but no more than 6 hours of Stat 7710, 7750, and 7760 can be counted towards the 15 hours. The applied sequence requirement can be satisfied by either Stat 7510/Stat 8220 or Stat 8310/8320. At most one course from Stat 7510 and Stat 8310 can be counted and at most one course from Stat 8220 and 8320 can be counted towards the 15 hours.

The plan of study must be approved by the Director of Graduate Studies of the Statistics Department and be completed with an average grade of B (3.0) or higher. Each student is encouraged to seek approval of his/her plan of study as soon as possible.

Courses

STAT 7002--Topics in Statistics-Biological/Physical/Mathematics (cr.arr.).Organized study of selected topics. Subjects and earnable credit may vary from semester to semester. Repeatable with departmental consent. Prerequisites: graduate standing and instructor's consent.

STAT 7020--Statistical Methods in the Health Sciences (3). Basic inference methods, both parametric and non-parametric, appropriate for answering questions arising in health sciences research. Computer exercises involving data from real experiments from health science area. Prerequisites: MATH 1100 or 1120 and graduate standing or instructor's consent.

STAT 7050--Connecting Statistics to Middle and Secondary Schools (3). Primarily for middle and secondary mathematics education majors.Uses standards-based curricular materials to demonstrate connections between college-level statistics and content taught in middle and secondary schools.

No credit toward a graduate degree in statistics. Prerequisites: graduate standing and an introductory course in statistics or MATH 2320 or instructor's consent.

STAT 7070--Statistical Methods for Research (3). Designed for graduate students who have no previous training in statistics. Topics include descriptive statistics, probability distributions, estimation, hypothesis testing, regression, and ANOVA. No credit toward a degree in statistics. Prerequisites: graduate standing and MATH 1100 or 1120.

STAT 7085--Problems in Statistics for Non-majors (cr.arr.). Approved reading and study, independent investigations, and reports on approved topics. Prerequisites: graduate standing and instructor's consent.

STAT 7110--Statistical Software and Data Analysis (3). Programming with major statistical packages emphasizing data management techniques and statistical analysis for regression, analysis of variance, categorical data, descriptive statistics, non-parametric analyses, and other selected topics. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7150--Applied Categorical Data Analysis (3). The study of statistical models and methods used in analyzing categorical data. The use of computing is emphasized and calculus is not required. No credit for students who have previously completed STAT 4830. No credit toward a graduate degree in statistics. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, or 4760/7760 or instructor's consent.

STAT 7210--Applied Nonparametric Methods (3). Statistical methods when the functional form of the population is unknown. Applications emphasized. Comparisons with parametric procedures, Goodness of-fit, chi-square, comparison of several populations, measures of correlation. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7310--Sampling Techniques (3). Theory of probability sampling designs; Unrestricted random sampling; Stratified sampling; Cluster sampling; Multistage or sub sampling; Ratio estimates; Regression estimates; Double sampling. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7410--Biostatistics (3). Study of statistical techniques for the design and analysis of clinical trials, laboratory studies and epidemiology. Topics include randomization, power and sample size calculation, sequential monitoring, carcinogenicity bioassay and case-cohort designs. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7420--Applied Survival Analysis (3). Parametric models; Kaplan-Meier estimator; nonparametric estimation of survival and cumulative hazard functions; log-rank test; Cox model; Stratified Cox model; additive hazards model partial likelihood; regression diagnostics; multivariate survival data. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710 or 4760/7760 or instructor's consent.

STAT 7430--Applied Longitudinal Data Analysis (3). Repeated measurements; event history studies; linear and nonlinear mixed effects models; growth models; marginal mean and rate models; pattern-mixture models; selection models; non-informative and informative drop-out; joint analysis of longitudinal and survival data. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, or 4760/7760 or instructor's consent.

STAT 7450--Applied Statistical Methods for Bioinformatics (3). Random variables; Point estimation; Multiple t-test; Likelihood principle; Analysis of variance; Probabilistic methods for sequence modeling; Gene expression analysis; Protein structure prediction; Genome analysis; Hierarchical clustering and Gene classification. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7510—Applied Statistical Models I (3). Introduction to applied linear models including regression (simple and multiple, subset selection, estimation and testing) and analysis of variance (fixed and random effects, multifactor models, contrasts, multiple testing). No credit towards a

graduate degree in statistics. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7530--Analysis of Variance (3). Study of analysis of variance and related modeling techniques for cases with fixed, random, and mixed effects. Exposure to designs other than completely randomized designs including factorial arrangements, repeated measures, nested, and unequal sample size designs. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710, 4760/7760, or instructor's consent.

STAT 7540--Experimental Design (3). Examination and analysis of modern statistical techniques applicable to experimentation in social, physical, or biological sciences. Prerequisites: graduate standing and STAT 3500 or 4510/7510 or 4530/7530 or instructor's consent.

STAT 7560--Applied Multivariate Data Analysis (3). Testing mean vectors; discriminant analysis; principal components; factor analysis; cluster analysis; structural equation modeling; graphics. Prerequisites: graduate standing and STAT 3500, 7070, 4710/7710 or 4760/7760. No credit toward a graduate degree in statistics.

STAT 7610--Applied Spatial Statistics (3). Introduction to spatial random processes, spatial point patterns, kriging, simultaneous and conditional autoregression, and spatial data analysis. Prerequisites: graduate standing and STAT 4510/7510 or instructor's consent. Recommended: Basic knowledge of calculus and matrices.

STAT 7640--Introduction to Bayesian Data Analysis (3). Bayes formulas; choices of prior; empirical Bayesian methods; hierarchical Bayesian methods; statistical computation; Bayesian estimation; model selection; predictive analysis; applications; Bayesian software. Prerequisites: graduate standing and STAT 3500 or 4510/7510 or instructor's consent.

STAT 7710--Introduction to Mathematical Statistics (3). (same as Mathematics [MATH] 7315). Introduction to theory of probability and statistics using concepts and methods of calculus. Prerequisites: graduate standing and MATH 2300 or instructor's consent. No credit MATH 7315.

STAT 7750--Introduction to Probability Theory (3). (same as Mathematics [MATH] 7320). Probability spaces; random variables and their distributions; repeated trials; probability limit theorems. Prerequisites: graduate standing and MATH 2300 or instructor's consent.

STAT 7760--Statistical Inference (3). (same as Mathematics [MATH] 7520). Sampling; point estimation; sampling distribution; tests of hypotheses; regression and linear hypotheses. Prerequisite: STAT 4750/7750 or instructor's consent.

STAT 7810—Nonparametric Methods (3). A first course in Non-parametric statistical methods based on ranks. Both theory and application are emphasized. Two-sample problems; K-sample problems; Tests for independence; Contingency tables; Goodness-of-fit tests. Prerequisites: graduate standing and STAT 4710/7710 or instructor's consent.

STAT 7830--Categorical Data Analysis (3). Discrete distributions; frequency data; multinomial data; chi-square and likelihood ratio tests; logistic regression; log linear models; rates; relative risks; random effects; case studies. Prerequisites: graduate standing and STAT 4710/7710 or instructor's consent.

STAT 7850--Introduction to Stochastic Processes (3). Study of random processes selected from: Markov chains, birth and death processes, random walks, Poisson processes, renewal theory, Brownian motion, Gaussian processes, white noise, spectral analysis, applications such as queuing theory, and sequential tests. Prerequisites: graduate standing and STAT 4750/7750 or instructor's consent.

STAT 7870--Time Series Analysis (3). A study of univariate and multivariate time series models and techniques for their analyses. Emphasis is on methodology rather than theory. Examples are drawn from a variety of areas including business, economics, and soil science. Prerequisites: graduate standing and STAT 7710 or 7760 or instructor's consent.

STAT 8085--Problems in Statistics for Majors - Masters (cr.arr.).Approved reading and study, independent investigations, and reports on approved topics. Prerequisites: graduate standing and instructor's consent.

STAT 8090--Master's Thesis Research in Statistics (cr.arr.).Graded on a S/U basis only.

STAT 8100--Special Topics in Statistics (cr.arr.). Prerequisites: graduate standing and instructor's consent.

STAT 8220—Applied Statistical Models II (3). Advanced applied linear models including mixed linear mixed models (fixed and random effects, variance components, correlated errors, split-plot designs, repeated measures, heterogeneous variance), generalized linear models (logistic and Poisson regression), nonlinear regression. No credit toward a graduate degree in statistics. Prerequisites: graduate standing and STAT 4510 or STAT 7510 or instructor's consent.

STAT 8310--Data Analysis I (3). Applications of linear models including regression (simple and multiple, subset selection, regression diagnostics), analysis of variance (fixed, random and mixed effects, contrasts, multiple comparisons) and analysis of covariance; alternative nonparametric methods. Prerequisites: graduate standing and STAT 4710/7710 or 4760/7760 or instructor's consent.

STAT 8320--Data Analysis II (3). Advanced applications including analysis of designs (e.g. repeated measures, hierarchical models, missing data), multivariate analysis (Hotelling's T2, MANOVA, discriminant analysis, principal components, factor analysis), nonlinear regression, generalized linear models, and categorical data analysis. Prerequisites: graduate standing and STAT 8310 or instructor's consent.

STAT 8330--Data Analysis III (3). An introduction to data analysis techniques associated with supervised and unsupervised statistical learning. Resampling methods, model selection, regularization, generalized additive models, trees, support vector machines, clustering, nonlinear dimension reduction. Prerequisites: graduate standing and STAT 8320 or instructor's consent.

STAT 8370--Statistical Consulting (3). Participation in statistical consulting under faculty supervision; Formulation of statistical problems; Planning of surveys and experiments; Statistical computing; Data analysis; Interpretation of results in statistical practice. Prerequisites: graduate standing and STAT 4760/7760 and 8320 or instructor's consent.

STAT 8410--Statistical Theory of Bioinformatics (3). Study of statistical theory and methods underpinning bioinformatics. Topics include statistical theory used in biotechnologies such as gene sequencing, gene alignments, microarrays, phylogentic trees, evolutionary models, proteomics and imaging. Prerequisites: graduate standing and STAT 4760/7760.

STAT 8640--Bayesian Analysis I (3). Bayes' theorem, subjective probability, non-informative priors, conjugate prior, asymptotic properties, model selection, computation, hierarchical models, hypothesis testing, inference, predication, applications. Prerequisites: graduate standing and STAT 4760/7760 and MATH 4140/7140 or instructor's consent.

STAT 8710--Intermediate Mathematical Statistics I (3). Sample spaces, probability and conditional probability, independence, random variables, expectation, distribution theory, sampling distributions, laws of large numbers and asymptotic theory, order statistics. Prerequisites: graduate standing and STAT 7760 or instructor's consent.

STAT 8720--Intermediate Mathematical Statistics II (3). Further development of estimation theory, including sufficiency, minimum variance principles and Bayesian estimation. Tests of hypotheses, including uniformly most powerful and likelihood ratio tests. Prerequisites: graduate standing and STAT 8710 or instructor's consent.

STAT 9085--Problems in Statistics for Majors - PhD (cr.arr.).Approved reading and study, independent investigations, and reports on approved topics. Prerequisites: graduate standing and instructor's consent.

STAT 9090--Doctoral Dissertation Research in Statistics (cr.arr.).Graded on a S/U basis only.

STAT 9100--Recent Developments in Statistics (3). The content of the course which varies from semester to semester, will be the study of some statistical theories or methodologies which are currently under development, such as bootstrapping, missing data, non-parametric regression, statistical computing, etc. Prerequisites: graduate standing, STAT 4760/7760 and instructor's consent.

STAT 9250--Statistical Computation and Simulation (3). Random number generation, acceptance/rejection methods; Monte Carlo; Laplace approximation; the EM algorithm; importance sampling; Markov chain Monte Carlo; Metropolis-Hasting algorithm; Gibbs sampling, marginal likelihood. Prerequisites: graduate standing and STAT 4760/7760 or instructor's consent.

STAT 9310--Theory of Linear Models (3). Theory of multiple regression and analysis of variance including matrix representation of linear models, estimation, testing hypotheses, model building, contrasts, multiple comparisons, and fixed and random effects. Prerequisites: graduate standing, STAT 4760/7760 and MATH 4140/7140, and instructor's consent.

STAT 9320--Advanced Linear Models (3). Advanced topics in the theory and application of linear models. Specific content varies with instructor. Prerequisites: graduate standing and STAT 9310 or instructor's consent.

STAT 9370--Multivariate Analysis (3). Distribution of sample correlation coefficients; Derivation of generalized T-squared and Wishart distributions; Distribution of certain characteristic roots, vectors; Test of hypotheses about covariance matrices and mean vectors; Discriminant analysis. Prerequisites: graduate standing and STAT 4760/7760 and MATH 4140/7140 or instructor's consent.

STAT 9410--Survival Analysis (3). Statistical failure models, Kaplan-Meier estimator, Log-rank test, Cox's regression model, Multivariate failure time date analysis, Counting process approaches. Prerequisites: graduate standing and STAT 4760/7760 or instructor's consent.

STAT 9510--Theory of Nonparametric Statistics (3). Estimation, hypothesis testing, confidence intervals, etc., when functional form of the population distribution is unknown. Prerequisites: graduate standing and STAT 4760/7760 or instructor's consent.

STAT 9530--Data Mining and Machine Learning Methods (3). Approaches to estimating unspecified relationships and findings unexpected patterns in high dimensional data. Computationally intensive methods including splines, classifications, tree-based and bagging methods, and support vector machines. Prerequisites: Stat 4110/7110, 4760/7760 and 8320 or instructor's consent.

STAT 9640--Bayesian Analysis II (3). Likelihood principle, decision theory, asymptotic properties, advanced topics in Bayesian analysis at the instructor's discretion. Prerequisites: graduate standing and STAT 8640 and 9710 or instructor's consent.

STAT 9710--Advanced Mathematical Statistics I (3). Theory of estimation and tests of hypotheses including sufficiency, completeness and exponential families; Neyman-Pearson lemma, most powerful tests, similarity and invariance; Bayes and minimum variance unbiased estimates; Confidence intervals and ellipsoids. Prerequisite: graduate standing and STAT 8720 or instructor's consent.

STAT 9720--Advanced Mathematical Statistics II (3). Asymptotic distributions of maximum likelihood estimators, chi-square and likelihood ratio test statistics. EM algorithm, bootstrap, and introduction to generalized linear models. Prerequisites: graduate standing and STAT 9710, MATH 4700/7700 or instructor's consent.

STAT 9810--Advanced Probability (3). (same as Mathematics 8480). Measure theoretic probability theory. Characteristic functions; conditional probability and expectation; sums of independent random variables including strong law of large numbers and central limit problem.

Prerequisites: graduate standing and STAT 4750/7750 or MATH 4700/7700 or instructor's consent.

STAT 9820--Stochastic Processes (3). (same as Mathematics 8680). Markov processes, martingales, orthogonal sequences, processes with independent and orthogonal increments, stationary, linear prediction. Prerequisite: graduate standing and STAT 9810 or instructor's consent.