STATISTICS

Department Website: https://stat.uchicago.edu

PROGRAM OF STUDY

The modern science of statistics involves the development of principles and methods for modeling uncertainty; for designing experiments, surveys, and observational programs; and for analyzing and interpreting empirical data. Mathematics plays a major role in all areas of statistics, from probability theory to data analysis. Statistics is an appropriate field for students with strong mathematical and computational skills and an interest in applying these skills to problems in the natural and social sciences. A program leading to the bachelor's degree in Statistics offers coverage of the principles and methods of statistics in combination with solid training in mathematics and computation. The major can provide appropriate preparation for graduate study in statistics or in other subjects with strong quantitative components. Students considering graduate study in statistics or related fields are encouraged to discuss their programs with the Departmental Adviser for Majors at an early stage, whether or not they plan to receive an undergraduate degree in Statistics.

Students who are majoring in other fields of study may also complete a minor in Statistics and are encouraged to discuss their course choices with the Departmental Adviser for Minors. Information on the minor follows the description of the major.

GENERAL COURSE INFORMATION

Courses at the 10000 or 20000 level are designed to provide instruction in statistics, probability, and statistical computation for students from all parts of the University. These courses differ in emphasis on theory or methods, in mathematical level, and in the direction of applications.

INTRODUCTORY COURSES AND SEQUENCES

To begin their studies in statistics, students can choose from several courses. Students and College advisers are encouraged to contact the Departmental Adviser for Introductory Courses for advice on choosing an appropriate first course.

Students with little or no math background who do not intend to continue on to more advanced statistics courses may take *either* STAT 20000 Elementary Statistics or STAT 20010 Elementary Statistics Through Case Study; enrolling in both is not permitted. Either course satisfies the general education requirement in the mathematical sciences. These courses are two variants of an introductory course that emphasizes concepts rather than statistical techniques. Neither STAT 20000 Elementary Statistics nor STAT 20010 Elementary Statistics Through Case Study may be taken by students with credit for STAT 22000 Statistical Methods and Applications, STAT 23400 Statistical Models and Methods, or more advanced courses in the Department of Statistics. Neither STAT 20000 Elementary Statistics nor STAT 20010 Elementary Statistics Through Case Study counts toward the major or minor in Statistics.

The sequence STAT 11800-11900 Introduction to Data Science I-II provides a computational introduction to statistical concepts, techniques, and applications to data analysis. STAT 11800-11900 Introduction to Data Science I-II has considerable overlap with STAT 22000 Statistical Methods and Applications, but has a more computational and less mathematical emphasis than STAT 22000 Statistical Methods and Applications. Neither STAT 11800 Introduction to Data Science I nor STAT 11900 Introduction to Data Science II can count toward the major in Statistics. STAT 11900 Introduction to Data Science II, but not STAT 11800 Introduction to Data Science I, can be used as an elective in the minor in Statistics.

Students with at least MATH 13100 Elem Functions and Calculus I or placement into MATH 15200 Calculus II or higher are encouraged to take STAT 22000 Statistical Methods and Applications instead of either STAT 20000 Elementary Statistics or STAT 20010 Elementary Statistics Through Case Study. Students with three quarters of calculus may choose either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods. Students may count either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods, but not both, toward the forty-two credits required for graduation.

STAT 22000 Statistical Methods and Applications is a general introduction to statistical concepts, techniques, and applications to data analysis and to problems in the design, analysis, and interpretation of experiments and observational programs. A score of 5 on the AP Statistics exam yields credit for STAT 22000 Statistical Methods and Applications, although this credit will not count toward the requirements for a major or minor in Statistics. STAT 22000 Statistical Methods and Applications can count toward the minor in Statistics, but not toward the major in Statistics.

STAT 23400 Statistical Models and Methods covers much of the same material as STAT 22000 Statistical Methods and Applications, but at a somewhat higher mathematical level. The course is a one-quarter introduction to statistics that is appropriate for any student with a good command of univariate calculus including sequences and series. STAT 23400 Statistical Models and Methods can count toward the minor in Statistics, but not toward the major in Statistics.

Students cannot hold credit for both STAT 22000 Statistical Methods and Applications and STAT 23400 Statistical Models and Methods. Students completing either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods forego their AP Statistics credit for STAT 22000 Statistical Methods and Applications.

STAT 24400-24500 Statistical Theory and Methods I-II is recommended for students who wish to have a thorough introduction to statistical theory and methodology. STAT 24400-24500 Statistical Theory and Methods I-II is more mathematically demanding than either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods. STAT 24400 Statistical Theory and Methods I assumes some familiarity with multivariate calculus, and STAT 24500 Statistical Theory and Methods II assumes some familiarity with linear algebra.

STAT 24410-24510 Statistical Theory and Methods Ia-IIa is an alternative version of STAT 24400-24500 Statistical Theory and Methods I-II that requires STAT 25100 Introduction to Mathematical Probability (or STAT 25150 Introduction to Mathematical Probability-A) as a prerequisite and that replaces some probability topics with additional statistical topics not normally covered in STAT 24400-24500 Statistical Theory and Methods I-II. STAT 24410-24510 Statistical Theory and Methods Ia-IIa is particularly well-suited for students with a strong mathematical background who are interested in more extensive coverage of probability and statistics. Students may count either STAT 24400 Statistical Theory and Methods I or STAT 24410 Statistical Theory and Methods Ia, but not both, toward the 4200 units of credit required for graduation. Similarly, students may count either STAT 24500 Statistical Theory and Methods II or STAT 24510 Statistical Theory and Methods IIa, but not both, and they may count either STAT 25100 Introduction to Mathematical Probability or STAT 25150 Introduction to Mathematical Probability-A, but not both, toward the 4200 units of credits required for graduation.

Students considering a major in Statistics are encouraged to begin with either STAT 24400-24500 Statistical Theory and Methods I-II or with the alternative sequence consisting of STAT 25100 Introduction to Mathematical Probability (or STAT 25150 Introduction to Mathematical Probability-A) followed by STAT 24410-24510 Statistical Theory and Methods Ia-IIa, rather than with STAT 23400 Statistical Models and Methods. Although students with a strong mathematical background can and do take either STAT 24400-24500 Statistical Theory and Methods I-II or the alternative sequence (STAT 25100 Introduction to Mathematical Probability and STAT 24410-24510 Statistical Theory and Methods Ia-IIa) without prior course work in statistics or probability, some students find it helpful to take either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods as preparation.

The core of the Statistics major consists of three courses: STAT 25100 Introduction to Mathematical Probability (or STAT 25150 Introduction to Mathematical Probability-A) and either STAT 24400-24500 Statistical Theory and Methods I-II or STAT 24410-24510 Statistical Theory and Methods Ia-IIa. Either of these is recommended as a three-quarter cognate sequence for students in the quantitative sciences and mathematics. Note that STAT 25100 Introduction to Mathematical Probability may be taken before, after, or concurrently with STAT 24400-24500 Statistical Theory and Methods I-II, though it is a prerequisite for STAT 24410-24510 Statistical Theory and Methods Ia-IIa.

Additional Courses in Statistical Theory, Methods, and Applications

For students interested in continuing their study of statistics beyond the introductory level, STAT 22200 Linear Models and Experimental Design, STAT 22400 Applied Regression Analysis (or STAT 22401 Regression Analysis for Health and Social Research), STAT 22600 Analysis of Categorical Data, STAT 22700 Biostatistical Methods, and STAT 27410 Introduction to Bayesian Data Analysis are recommended. Note that STAT 22400 Applied Regression Analysis and STAT 22401 Regression Analysis for Health and Social Research are highly similar to each other, and students may only take one of them for credit, not both. They are considered to be interchangeable in the major and minor in Statistics. Also, because there is some overlap between STAT 22600 Analysis of Categorical Data and STAT 22700 Biostatistical Methods, only one of these two courses, not both, may be counted toward a major or minor in Statistics. The courses STAT 22200 Linear Models and Experimental Design, STAT 22400 Applied Regression Analysis (or STAT 22401 Regression Analysis for Health and Social Research), STAT 22600 Analysis of Categorical Data, and STAT 27410 Introduction to Bayesian Data Analysis may be taken in any order. Each presumes two quarters of calculus and a previous course in statistics (STAT 22000 Statistical Methods and Applications or higher). STAT 22700 Biostatistical Methods has STAT 22400 Applied Regression Analysis (or STAT 22401 Regression Analysis for Health and Social Research) as a prerequisite.

For students who have completed STAT 24400-24500 Statistical Theory and Methods I-II and are interested in more advanced statistical methodology courses, STAT 24620 Multivariate Statistical Analysis: Applications and Techniques, STAT 26100 Time Dependent Data, STAT 26300 Introduction to Statistical Genetics , STAT 27400 Nonparametric Inference, STAT 27850 Multiple Testing, Modern Inference, and Replicability, and STAT 34300 Applied Linear Stat Methods are recommended. Many other graduate courses in Statistics offer opportunities for further study of statistical theory, methods, and applications. For details, consult the instructor or the Departmental Adviser for Majors, or visit the Graduate Announcements (http://graduateannouncements.uchicago.edu/departmentofstatistics/).

Courses in Probability

Students interested in probability can begin with STAT 25100 Introduction to Mathematical Probability or STAT 25150 Introduction to Mathematical Probability-A, which can be taken separately from any Statistics courses and can be supplemented with more advanced probability courses, such as STAT 25300 Introduction to Probability Models, STAT 25211 Introduction to Random Matrices, or MATH 23500 Markov Chains, Martingales, and Brownian Motion. Students with a strong mathematical background can take STAT 31200 Introduction to Stochastic Processes I, STAT 38100 Measure-Theoretic Probability I, and STAT 38300 Measure-Theoretic Probability III. Note that because there is some overlap between MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, and STAT 31200 Introduction to Stochastic Processes I, only one of these three courses may be counted toward a major in Statistics.

Courses in Machine Learning

A student with a strong computer science background could take STAT 27700 Mathematical Foundations of Machine Learning and STAT 27725 Machine Learning. Other courses in the category of machine learning include the advanced statistical methodology courses STAT 24620 Multivariate Statistical Analysis: Applications and Techniques and STAT 27400 Nonparametric Inference. Graduate course offerings in machine learning include STAT 37601 Machine Learning and Large-Scale Data Analysis, STAT 37710 Machine Learning, as well as more advanced graduate courses.

Courses in Optimization

A student with a strong mathematical background could take STAT 28000 Optimization. Graduate course offerings in optimization include STAT 31015 Mathematical Computation IIA: Convex Optimization and STAT 31020 Mathematical Computation IIB: Nonlinear Optimization.

Grading

Students who are majoring or minoring in Statistics must receive a quality grade of at least C in all of the courses counted toward their major or minor program in Statistics. In addition, students who are majoring in Statistics must receive quality grades of at least C+ in both STAT 24400 Statistical Theory and Methods I and STAT 24500 Statistical Theory and Methods II (or at least C in both STAT 24410 Statistical Theory and Methods Ia and STAT 24510 Statistical Theory and Methods IIa). Subject to College and divisional regulations, and with the consent of the instructor, students may register for either quality grades or for Pass/Fail grading in any 20000-level Statistics course, other than STAT 29700 Undergraduate Research or STAT 29900 Bachelor's Paper, that is not counted toward a major or minor in Statistics. A grade of Pass is given only for work of C– quality or higher.

The following policy applies to students who wish to receive a mark of I for a Statistics course. In addition to submitting the official Incomplete Form required by the College, students must have completed at least half of the total required course work with a grade of C– or better, and they must be unable to complete the remaining course work by the end of the quarter due to an emergency. Students requesting a mark of I for STAT 20000 Elementary Statistics, STAT 20010 Elementary Statistics Through Case Study, STAT 22000 Statistical Methods and Applications, or STAT 23400 Statistical Models and Methods must obtain approval from both the current instructor and the Departmental Adviser for Introductory Courses.

Program Requirements for Majors

Every candidate must obtain approval of his or her course program from the Departmental Adviser for Majors. Students majoring in Statistics should meet the general education requirement in mathematical sciences with courses in calculus. The major program includes four additional prescribed mathematics courses, four prescribed statistics courses, and two prescribed computer science courses. Students are advised to complete the four mathematics courses by the end of their third year. Additional requirements include four approved elective courses in Statistics. The BS also requires an additional prescribed mathematics course and an approved, coherent, three-quarter sequence at the 20000 level in a field to which statistics can be applied. Students who are majoring in Statistics must receive quality grades of at least C+ in both STAT 24400-24500 Statistical Theory and Methods I-II (or at least C in both STAT 24410-24510 Statistical Theory and Methods Ia-IIa), and at least C in all other courses counted toward the Statistics major. A grade of Pass is not acceptable for any of these courses.

Prescribed Mathematics Courses

CALCULUS III REQUIREMENT (both BA and BS)

One of the following courses is required:		100
MATH 18300	Mathematical Methods in the Physical Sciences I	
MATH 13300	Elementary Functions and Calculus III	
MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
MATH 16310	Honors Calculus III (IBL)	

Students who plan to take MATH 18400 Mathematical Methods in the Physical Sciences II are recommended to take MATH 18300. MATH 13300 or MATH 15300 are not a prerequisite for MATH 18400. See below for allowed and not allowed pathways.

LINEAR ALGEBRA REQUIREMENT (both BA and BS)

One of the following courses is required:		100
STAT 24300	Numerical Linear Algebra	
MATH 20250	Abstract Linear Algebra	
MATH 20700	Honors Analysis in Rn I	

Note that MATH 19620 Linear Algebra does not meet the Linear Algebra Requirement.

MULTIVARIATE CALCULUS AND OTHER REQUIREMENTS

For the BA, one of the following pairs of courses is required:		200
MATH 18400 & MATH 18500	Mathematical Methods in the Physical Sciences II and Mathematical Methods in the Physical Sciences III	
MATH 20400-20500	Analysis in Rn II-III	
MATH 20410 & MATH 20510	Analysis in Rn II (accelerated) and Analysis in Rn III (accelerated)	
MATH 20420 & MATH 20520	Analysis in Rn II (IBL) and Analysis in Rn III (IBL)	
MATH 20800-20900	Honors Analysis in Rn II-III	

Alternatively, STAT 28200 Dynamical Systems with Applications can be substituted for MATH 18500.

For the BS, students must take one course from each of the three groups below.

GROUP 1:		100
MATH 18400	Mathematical Methods in the Physical Sciences II	
MATH 20500	Analysis in Rn III	
MATH 20510	Analysis in Rn III (accelerated)	
MATH 20520	Analysis in Rn III (IBL)	
MATH 20900	Honors Analysis in Rn III	

GROUP 2:		100
MATH 18500	Mathematical Methods in the Physical Sciences III	
MATH 27300	Basic Theory of Ordinary Differential Equations	
STAT 28200	Dynamical Systems with Applications	

GROUP 3:		100
STAT 28000	Optimization	
MATH 21100	Basic Numerical Analysis	
MATH 21200	Advanced Numerical Analysis	

For both the BA and BS, please note that not all combinations of Calculus III and Multivariate Calculus courses are allowed. Specifically, only MATH 18300 is a prerequisite for MATH 18400. MATH 13300 or MATH 15300 or MATH 16300 or MATH 16310 alone is not a prerequisite for MATH 18400 unless students have completed a course in Linear Algebra (MATH 19620 or MATH 20250 or STAT 24300). Specifically, the following paths are allowed:

MATH 18300-18400

(MATH 13300 or MATH 15300) - MATH 19620-MATH 18400

(MATH 13300 or MATH 15300) - MATH 15910-MATH 20250-MATH 18400

(MATH 16300 or MATH 16310) - (STAT 24300 or MATH 20250) - MATH 18400

(MATH 16300 or MATH 16310) - (MATH 20300-MATH 20400-MATH 20500 or MATH 20310-MATH 20410-MATH 20510 or MATH 20700-MATH 20800-MATH 20900)

(MATH 13300 or MATH 15300 or MATH 18300) - MATH 15910 - (MATH 20300-MATH 20400-MATH 20500 or MATH 20310-MATH 20410-MATH 20510 or MATH 20700-MATH 20800-MATH 20900)

Note none of MATH 15910, MATH 19620, MATH 20300, and MATH 20310 in the pathways above count toward the Statistics BA or BS. MATH 20400 or MATH 20410 or MATH 20800 does not count toward the Statistics BS.

The following paths are typically not possible because in each case the prerequisite for the second course in the sequence is not met.

(MATH 13300 or MATH 15300 or MATH 16300 or MATH 16310)-MATH 18400

(MATH 13300 or MATH 15300) - (STAT 24300 or MATH 20250)-MATH 18400

Prescribed Statistics Courses

The four prescribed Statistics courses are STAT 25100 Introduction to Mathematical Probability (or STAT 25150 Introduction to Mathematical Probability-A or MATH 23500 Markov Chains, Martingales, and Brownian Motion), STAT 24400-24500 Statistical Theory and Methods I-II (or STAT 24410-24510 Statistical Theory and

Methods Ia-IIa), and one of the following three courses: STAT 22400 Applied Regression Analysis or STAT 22401 Regression Analysis for Health and Social Research or STAT 34300 Applied Linear Stat Methods.

It is recommended that students who have had some multivariable calculus begin the major by taking either STAT 25100 Introduction to Mathematical Probability or STAT 24400 Statistical Theory and Methods I as their first course in probability and statistics. An alternative route to beginning the major would be to first take either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods, neither of which count toward the major, but which could serve as a prerequisite for courses such as STAT 22400 Applied Regression Analysis, STAT 22200 Linear Models and Experimental Design, STAT 22600 Analysis of Categorical Data, and STAT 27410 Introduction to Bayesian Data Analysis which do count toward the major. This second path is recommended for students who need additional time to complete multivariable calculus and linear algebra prerequisites and who want to get started on the major in the meantime.

Electives

Candidates for the BA are required to take four electives, at least two of which must be on List B below. The remaining two electives may be from either List B or C. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the BA. Similarly, students may count only one of the following three courses: MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, or STAT 31200 Introduction to Stochastic Processes I, toward the BA. If MATH 23500 Markov Chains, Martingales, and Brownian Motion is counted in place of STAT 25100 Introduction to Mathematical Probability in the Statistics BA, then MATH 23500 Markov Chains, Martingales, and Brownian Motion cannot also be counted as an elective in the Statistics BA.

Candidates for the BS are required to take four electives. A candidate for the BS who has *not* taken STAT 34300 Applied Linear Stat Methods as one of the four prescribed statistics courses must take at least one elective from List A below, a second elective from List B, and the remaining two electives may be from either List B or C. A candidate for the BS who *has* taken STAT 34300 Applied Linear Stat Methods as one of the four prescribed statistics courses must take at least two electives from List B and the remaining two electives may be from either List B or C. For the BS in Statistics, STAT 28000 Optimization counts as a List C elective only if MATH 21100 Basic Numerical Analysis or MATH 21200 Advanced Numerical Analysis is also included in the program. In other words, students cannot double-count STAT 28000 Optimization toward both the four-elective requirement and the requirement to take one of STAT 28000 Optimization, MATH 21100 Basic Numerical Analysis, and MATH 21200 Advanced Numerical Analysis. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the BS. Similarly, students may count only one of the following three courses: MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, or STAT 31200 Introduction to Stochastic Processes I, toward the BS. If MATH 23500 Markov Chains, Martingales, and Brownian Motion is counted in place of STAT 25100 Introduction to Mathematical Probability in the Statistics BS, then MATH 23500 Markov Chains, Martingales, and Brownian Motion cannot also be counted as an elective in the Statistics BS.

Note: The following lists may change from time to time as courses change and new courses are added. Please consult the Departmental Adviser for Majors for approval of your electives.

LIST A: Advanced Statistical Methodology

STAT 24620	Multivariate Statistical Analysis: Applications and Techniques
STAT 24630	Causal Inference Methods and Case Studies
STAT 26100	Time Dependent Data
STAT 26300	Introduction to Statistical Genetics
STAT 27400	Nonparametric Inference
STAT 27850	Multiple Testing, Modern Inference, and Replicability
Some additional graduate courses in Statistics (must be approved by Departmental Adviser for Majors)	

LIST B: Statistical Methodology

STAT 22200	Linear Models and Experimental Design
STAT 22600	Analysis of Categorical Data [*]
STAT 22700	Biostatistical Methods [*]
STAT 24620	Multivariate Statistical Analysis: Applications and Techniques
STAT 24630	Causal Inference Methods and Case Studies
STAT 26100	Time Dependent Data
STAT 26300	Introduction to Statistical Genetics
STAT 27400	Nonparametric Inference
STAT 27410	Introduction to Bayesian Data Analysis
STAT 27420	Introduction to Causality with Machine Learning
STAT 27850	Multiple Testing, Modern Inference, and Replicability

STAT 27855	Hypothesis Testing with Empirical Bayes Methodology
STAT 35800	Statistical Applications
STAT 37601	Machine Learning and Large-Scale Data Analysis
Some additional graduate courses in Statistics (must be approved by Departmental Adviser for Majors)	

*   Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the major.

LIST C: Other Upper Level/Graduate Courses

MATH 23500	Markov Chains, Martingales, and Brownian Motion [*]
STAT 24310	Numerical Linear Algebra: An Introduction to Computation
STAT 25211	Introduction to Random Matrices
STAT 25300	Introduction to Probability Models [*]
STAT 27725	Machine Learning
STAT 27815	Practical R Programming
STAT 28000	Optimization [**]
STAT 30900	Mathematical Computation I: Matrix Computation Course
STAT 31015	Mathematical Computation IIA: Convex Optimization
STAT 31020	Mathematical Computation IIB: Nonlinear Optimization
STAT 31150	Inverse Problems and Data Assimilation
STAT 31200	Introduction to Stochastic Processes I [*]
STAT 37710	Machine Learning [***]
STAT 37711	Foundations of Machine Learning and AI - Part I [***]
STAT 38100	Measure-Theoretic Probability I
STAT 38300	Measure-Theoretic Probability III
STAT 39000	Stochastic Calculus
Some additional graduate courses in Statistics (must be approved by Departmental Adviser for Majors)	

*   Students may count only one of the following three courses: MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, or STAT 31200 Introduction to Stochastic Processes I, toward the major. If MATH 23500 Markov Chains, Martingales, and Brownian Motion is counted in place of STAT 25100 Introduction to Mathematical Probability, then it cannot also count as an elective.

**   For the BA in Statistics, STAT 28000 Optimization counts as a List C elective. For the BS in Statistics, STAT 28000 Optimization counts as a List C elective only if MATH 21100 Basic Numerical Analysis or MATH 21200 Advanced Numerical Analysis is also included in the program. In other words, for the BS, students cannot double-count STAT 28000 Optimization toward both the four-elective requirement and the requirement to take at least one of STAT 28000 Optimization, MATH 21100 Basic Numerical Analysis, and MATH 21200 Advanced Numerical Analysis.

***   Students may count either STAT 37710 Machine Learning or STAT 37711 Foundations of Machine Learning and AI - Part I but not both to the major.

COMPUTER SCIENCE REQUIREMENT

Candidates for either the BA or the BS are required to take CMSC 14100 Introduction to Computer Science I-CMSC 14200 Introduction to Computer Science II. Students with placement into CMSC 14200 Introduction to Computer Science II or higher must complete the course they are placed into.

BS Requirement of Three-Quarter Sequence in a Field to Which Statistics Can Be Applied

Candidates for the BS (but not the BA) are required to take an approved, coherent, three-quarter sequence at the 20000 level in a field to which statistics can be applied. Generally this sequence should be in the natural or social sciences, but a sequence in another discipline may be acceptable. Courses in MATH or CMSC may not be used for this requirement. Sequences in which earlier courses are prerequisites for later ones are preferred. Example sequences include BIOS 20198 Biodiversity-BIOS 20196 Ecology and Conservation-BIOS 23406 Biogeography; CHEM 22000-22100-22200 Organic Chemistry I-II-III; CHEM 26100-26200-26300 Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics; ECON 20000-20100-20200 The Elements of Economic Analysis I-II-III; GEOS 21000 Mineralogy-GEOS 21100 Introduction to Petrology-GEOS 21200 Physics of the Earth; and PHYS 23410 Quantum Mechanics I-PHYS 23510 Quantum Mechanics II-PHYS 24310 Advanced Quantum Mechanics. All sequences must be approved by the Departmental Adviser for Majors.

Summary of Requirements for the BA in Statistics

GENERAL EDUCATION

One of the following sequences: *		200
MATH 13100-13200	Elementary Functions and Calculus I-II	
MATH 15100-15200	Calculus I-II	
MATH 16100-16200	Honors Calculus I-II	
MATH 16110-16210	Honors Calculus I-II (IBL)	
Total Units		**200**

MAJOR

One of the following: *		100
MATH 18300	Mathematical Methods in the Physical Sciences I	
MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
MATH 16310	Honors Calculus III (IBL)	
MATH 13300	Elementary Functions and Calculus III	
One of the following course pairs:		200
MATH 18400 & MATH 18500	Mathematical Methods in the Physical Sciences II and Mathematical Methods in the Physical Sciences III	
MATH 18400 & STAT 28200	Mathematical Methods in the Physical Sciences II and Dynamical Systems with Applications	
MATH 20400-20500	Analysis in Rn II-III	
MATH 20410 & MATH 20510	Analysis in Rn II (accelerated) and Analysis in Rn III (accelerated)	
MATH 20800-20900	Honors Analysis in Rn II-III	
One of the following:		100
STAT 24300	Numerical Linear Algebra	
STAT 24310	Numerical Linear Algebra: An Introduction to Computation	
MATH 20250	Abstract Linear Algebra	
MATH 20700	Honors Analysis in Rn I	
One of the following:		100
STAT 24400	Statistical Theory and Methods I	
STAT 24410	Statistical Theory and Methods Ia	
One of the following:		100
STAT 24500	Statistical Theory and Methods II	
STAT 24510	Statistical Theory and Methods IIa	
One of the following:		100
STAT 25100	Introduction to Mathematical Probability	
STAT 25150	Introduction to Mathematical Probability-A	
MATH 23500	Markov Chains, Martingales, and Brownian Motion	
One of the following:		100
STAT 22400	Applied Regression Analysis	
STAT 22401	Regression Analysis for Health and Social Research	
STAT 34300	Applied Linear Stat Methods	
The following sequence:		200
CMSC 14100 & CMSC 14200	Introduction to Computer Science I and Introduction to Computer Science II	
Four approved elective courses in Statistics **		400
Total Units		**1400**

*   Credit may be granted by examination. Students who plan to take MATH 18400 Mathematical Methods in the Physical Sciences II are recommended to take MATH 18300 Mathematical Methods in the Physical Sciences I. MATH 13300 Elementary Functions and Calculus III or MATH 15300 Calculus III is not a prerequisite for MATH 18400 Mathematical Methods in the Physical Sciences II. See the section "Prescribed Mathematics Courses" above for allowed and not possible pathways.

** At least two of the electives must be on List B. The remaining two electives may be from either List B or C. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the BA. Students may count only one of the following three courses: MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, or STAT 31200 Introduction to Stochastic Processes I toward the BA. If MATH 23500 Markov Chains, Martingales, and Brownian Motion is counted in place of STAT 25100 Introduction to Mathematical Probability, then it cannot also count as an elective. If STAT 24310 Numerical Linear Algebra: An Introduction to Computation is counted in place of STAT 24300 Numerical Linear Algebra, then it cannot also count as an elective.

Summary of Requirements for the BS in Statistics

GENERAL EDUCATION

One of the following sequences: [*]		200
MATH 13100-13200	Elementary Functions and Calculus I-II	
MATH 15100-15200	Calculus I-II	
MATH 16100-16200	Honors Calculus I-II	
MATH 16110-16210	Honors Calculus I-II (IBL)	
Total Units		200

MAJOR

One of the following: [*]		100
MATH 18300	Mathematical Methods in the Physical Sciences I	
MATH 15300	Calculus III	
MATH 16300	Honors Calculus III	
MATH 16310	Honors Calculus III (IBL)	
MATH 13300	Elementary Functions and Calculus III	
One of the following:		100
MATH 18400	Mathematical Methods in the Physical Sciences II	
MATH 20500	Analysis in Rn III	
MATH 20510	Analysis in Rn III (accelerated)	
MATH 20900	Honors Analysis in Rn III	
One of the following:		100
MATH 18500	Mathematical Methods in the Physical Sciences III	
MATH 27300	Basic Theory of Ordinary Differential Equations	
STAT 28200	Dynamical Systems with Applications	
One of the following:		100
STAT 24300	Numerical Linear Algebra	
STAT 24310	Numerical Linear Algebra: An Introduction to Computation	
MATH 20250	Abstract Linear Algebra	
MATH 20700	Honors Analysis in Rn I	
One of the following:		100
STAT 28000	Optimization	
MATH 21100	Basic Numerical Analysis	
MATH 21200	Advanced Numerical Analysis	
One of the following:		100
STAT 24400	Statistical Theory and Methods I	
STAT 24410	Statistical Theory and Methods Ia	
One of the following:		100
STAT 24500	Statistical Theory and Methods II	
STAT 24510	Statistical Theory and Methods IIa	
One of the following:		100
STAT 25100	Introduction to Mathematical Probability	
STAT 25150	Introduction to Mathematical Probability-A	
MATH 23500	Markov Chains, Martingales, and Brownian Motion	
One of the following:		100
STAT 22400	Applied Regression Analysis	

STAT 22401	Regression Analysis for Health and Social Research	
STAT 34300	Applied Linear Stat Methods	
The following sequence:		200
CMSC 14100 & CMSC 14200	Introduction to Computer Science I and Introduction to Computer Science II	
Four approved elective courses in Statistics [**]		400
A coherent three-quarter sequence at the 20000 level in a field to which statistics can be applied [***]		300
Total Units		1800

[*]   Credit may be granted by examination. Students who plan to take MATH 18400 Mathematical Methods in the Physical Sciences II are recommended to take MATH 18300 Mathematical Methods in the Physical Sciences I. MATH 13300 Elementary Functions and Calculus III or MATH 15300 Calculus III is not a prerequisite for MATH 18400 Mathematical Methods in the Physical Sciences II. See the section "Prescribed Mathematics Courses" above for the allowed and not possible pathways.

[**]   A candidate for the BS who has *not* taken STAT 34300 Applied Linear Stat Methods as one of the four prescribed statistics courses must take at least one elective from List A, a second elective from List B, and the remaining two electives may be from either List B or C. A candidate for the BS who *has* taken STAT 34300 Applied Linear Stat Methods as one of the four prescribed statistics courses must take at least two electives from List B and the remaining two electives may be from either List B or C. For the BS in Statistics, STAT 28000 Optimization counts as a List C elective only if MATH 21100 Basic Numerical Analysis or MATH 21200 Advanced Numerical Analysis is also included in the program. In other words, students cannot double-count STAT 28000 Optimization toward both the four-elective requirement and the requirement to take at least one of STAT 28000 Optimization, MATH 21100 Basic Numerical Analysis, and MATH 21200 Advanced Numerical Analysis. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the BS. Students may count only one of the following three courses: MATH 23500 Markov Chains, Martingales, and Brownian Motion, STAT 25300 Introduction to Probability Models, or STAT 31200 Introduction to Stochastic Processes I toward the BS. If MATH 23500 Markov Chains, Martingales, and Brownian Motion is counted in place of STAT 25100 Introduction to Mathematical Probability, then it cannot also count as an elective. If STAT 24310 Numerical Linear Algebra: An Introduction to Computation is counted in place of STAT 24300 Numerical Linear Algebra, then it cannot also count as an elective.

[***]   Generally, this sequence should be in the natural or social sciences, but a sequence in another discipline may be acceptable. Courses in MATH or CMSC may not be used for this requirement. Sequences in which earlier courses are prerequisites for later ones are preferred. Example sequences include BIOS 20198 Biodiversity-BIOS 20196 Ecology and Conservation-BIOS 23406 Biogeography; CHEM 22000-22100-22200 Organic Chemistry I-II-III; CHEM 26100-26200-26300 Quantum Mechanics; Thermodynamics; Chemical Kinetics and Dynamics; ECON 20000-20100-20200 The Elements of Economic Analysis I-II-III; ECON 20010-20110-20210 The Elements of Economic Analysis: Honors I-II-III; GEOS 21000 Mineralogy-GEOS 21100 Introduction to Petrology-GEOS 21200 Physics of the Earth; and PHYS 23410 Quantum Mechanics I-PHYS 23510 Quantum Mechanics II and PHYS 24310 Advanced Quantum Mechanics. All sequences must be approved by the Departmental Adviser for Majors.

Honors

The BA or BS with honors is awarded to students with a Statistics BA or BS who have a GPA of 3.25 or higher overall and 3.5 or higher in the courses in the major and also complete an approved honors paper (STAT 29900 Bachelor's Paper). This paper is typically based on a structured research program that the student undertakes, with supervision by a faculty member in the Department of Statistics, in the first quarter of the student's fourth year. A student who wishes to write the honors paper must meet the following deadlines: (1) by the Friday of the fifth week of the first quarter of the student's fourth year, the student must submit the adviser's name (must be a faculty member in the Department of Statistics), tentative thesis title, and name of the second reader; (2) enroll in STAT 29900 in the second quarter of the student's fourth year, with a good draft of the thesis due by the first day of exam period; and (3) submit the final draft by the fifth week of the third quarter of the student's fourth year. Eligible students who wish to be considered for honors should consult the Departmental Adviser for Majors before the end of their third year. (These deadlines assume that the student is graduating in Spring Quarter of fourth year. Students graduating in a different quarter should consult the Departmental Adviser for Majors for deadlines.) The research paper or project used to meet this requirement may not be used to meet the bachelor's paper or project requirement in another major or course. NOTE: Credit for STAT 29900 Bachelor's Paper will not count towards the courses required for a major in Statistics.

Joint BA/MS or BS/MS in Statistics

This program enables unusually well-qualified undergraduate students to complete an MS in Statistics along with a BA or BS during their four years at the College. The BA or BS can be in any field, not necessarily Statistics. Outstanding undergraduates in any major are welcome to apply.

Only a small number of students will be selected for the program through a competitive admissions process. Participants must apply to the MS program in Statistics by June 1 of their third year for admission to candidacy for an MS in Statistics during their fourth year. To be considered, students should have completed almost all of their undergraduate requirements, including all of their general education and language competence requirements, by the end of their third year. They should also have completed, at a minimum, STAT 24400-24500 Statistical Theory and Methods I-II (or STAT 24410-24510 Statistical Theory and Methods Ia-IIa) with A or A- grades and all the mathematics requirements for the Statistics BA with very high grades. While these are the minimum criteria, admission is competitive, and additional qualifications may be needed. Interested students are strongly encouraged to consult both the Departmental Adviser for Majors and their College adviser early in their third year.

Participants in the joint BA/MS or BS/MS program must meet the same requirements as students in the MS program in Statistics. Of the nine courses that are required at the appropriate level, up to two may also meet the requirements of an undergraduate major and/or minor, while the others may count as general elective credit toward the undergraduate degree. For example, STAT 24410-24510 Statistical Theory and Methods Ia-IIa, which satisfy requirements for the MS in Statistics, could also be used to satisfy requirements of a BA or BS program in Statistics. At least six of the courses counting toward the MS degree must be undertaken in the fourth year.

Other requirements include a master's paper and participation in the Consulting Program of the Department of Statistics. For details on requirements, visit stat.uchicago.edu/academics/graduate-programs/graduate-student-resources/academic-life/requirements-and-regulations-for-ms-candidates (https://stat.uchicago.edu/academics/graduate-programs/graduate-student-resources/academic-life/requirements-and-regulations-for-ms-candidates/).

Minor Program in Statistics

The Statistics minor focuses on statistical methodology, in contrast to the Statistics major, which has a substantial theoretical component. The minor in Statistics requires five courses, some prescribed and some elective, chosen in consultation with the Departmental Adviser for Minors. Not every combination of elective courses is allowed. Generally, no more than two electives may be satisfied by courses offered by departments other than the Department of Statistics. Students are encouraged to obtain course advising early from the Departmental Adviser for Minors. By the end of Spring Quarter of the student's third year, a student who wishes to complete the Statistics minor must complete the Consent to Complete a Minor Program Form (https://humanities-web.s3.us-east-2.amazonaws.com/college-prod/s3fs-public/documents/Consent_Minor_Program.pdf) to obtain formal approval of their degree program from the Departmental Adviser for Minors.

The core of the Statistics minor consists of STAT 22400 Applied Regression Analysis (or STAT 22401 Regression Analysis for Health and Social Research) and either STAT 22200 Linear Models and Experimental Design or STAT 22600 Analysis of Categorical Data (or both). These three courses may be taken in any order after meeting the prerequisite of at least two quarters calculus and one of the introductory statistics courses: STAT 22000 Statistical Methods and Applications, STAT 23400 Statistical Models and Methods, STAT 24500 Statistical Theory and Methods II, STAT 24510 Statistical Theory and Methods IIa, or AP Statistics credit. STAT 11900 Introduction to Data Science II is also allowed to fulfill the introductory statistics prerequisite requirement.

An approved substitute for STAT 22600 Analysis of Categorical Data is PBHS 32700 Biostatistical Methods (also designated as STAT 22700 Biostatistical Methods), which requires STAT 22400 Applied Regression Analysis as prerequisite and is offered by the Department of Public Health Sciences. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the Statistics minor. STAT 22700 Biostatistical Methods does not count against the limit of no more than two electives from outside the Department of Statistics.

To complete the five-course minor, students must choose from among the approved electives listed below. Generally, no more than two electives may be satisfied by courses offered by departments other than the Department of Statistics. Students may petition the Departmental Adviser for Minors to include more than two electives from outside the Department of Statistics. Regardless, at most one elective can be satisfied by a course offered by the Booth School of Business. Further, due to the course grading policies of the Booth School of Business, their 40000-level courses cannot be counted toward the Statistics minor if taken during the quarter in which the student will graduate from the College.

STAT 11900 Introduction to Data Science II and either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods, but not both, may be used as electives in the Statistics minor if taken prior to any other courses for which at least STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods is prerequisite and before either of STAT 24500 Statistical Theory and Methods II or STAT 24510 Statistical Theory and Methods IIa. STAT 11900 Introduction to Data Science II can only be used as an elective in the Statistics minor if the student also completes STAT 11800 Introduction to Data Science I (which cannot be included in a Statistics minor).

Students should note that STAT 11900 Introduction to Data Science II is a requirement for the Data Science minor and no course may be counted toward multiple minors. Likewise, if either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods is used to fulfill a requirement for any major(s), other minors, or general education requirements, then neither course may be used to fulfill a requirement in the

Statistics minor. Students may not use AP credit for STAT 22000 Statistical Methods and Applications to fulfill a requirement for the Statistics minor.

The list of courses approved for the minor may change from time to time as courses change and new courses are added. Please consult the Departmental Adviser for Minors for approval of your minor program plan. Students may petition the Departmental Adviser for Minors for approval of another course. Such courses must have a minimum statistics prerequisite of introductory statistics (STAT 22000 Statistical Methods and Applications, STAT 23400 Statistical Models and Methods, STAT 24500 Statistical Theory and Methods II, or STAT 24510 Statistical Theory and Methods IIa), incorporate a considerable amount of data analysis, and cannot substantially overlap with the topics covered in departmental courses or other courses in the student's minor program.

No courses in the Statistics minor can be double-counted with the student's major(s), other minors, or general education requirements. An approved elective must replace any course required for the Statistics minor that is used to meet the requirements for any major(s), other minors, or general education requirements.

The following courses offered by the Department of Statistics cannot be included in a Statistics minor: STAT 11800 Introduction to Data Science I, STAT 20000 Elementary Statistics, STAT 20010 Elementary Statistics Through Case Study, STAT 24300 Numerical Linear Algebra, STAT 24400 Statistical Theory and Methods I, STAT 24410 Statistical Theory and Methods Ia, STAT 25100 Introduction to Mathematical Probability, STAT 25150 Introduction to Mathematical Probability-A, STAT 25211 Introduction to Random Matrices, STAT 25300 Introduction to Probability Models, STAT 28000 Optimization, STAT 28200 Dynamical Systems with Applications, STAT 29700 Undergraduate Research, or any graduate courses in probability. In addition, CMSC 25400 Machine Learning (also designated as STAT 27725 Machine Learning) cannot be included in the Statistics minor.

Students who are minoring in Statistics must receive a quality grade of at least C in all of the courses counted toward the minor. A grade of Pass is not acceptable for any of these courses. More than half of the courses counted toward the Statistics minor must be met by registering for courses bearing University of Chicago course numbers.

Summary of Requirements for the Minor in Statistics

One of the following courses: [*]		100
STAT 22400	Applied Regression Analysis [*]	
STAT 22401	Regression Analysis for Health and Social Research	
One of the following: [**]		100
STAT 22200	Linear Models and Experimental Design [*]	
STAT 22600	Analysis of Categorical Data [*], [***]	
Three approved electives [****]		300
Total Units		500

[*]   STAT 22200 Linear Models and Experimental Design, STAT 22400 Applied Regression Analysis, and STAT 22600 Analysis of Categorical Data may be taken in any order after meeting the prerequisite of at least two quarters calculus and introductory statistics: STAT 22000 Statistical Methods and Applications, STAT 23400 Statistical Models and Methods, STAT 24500 Statistical Theory and Methods II, STAT 24510 Statistical Theory and Methods IIa, or AP credit for STAT 22000 Statistical Methods and Applications. STAT 11900 Introduction to Data Science II is also allowed to fulfill the introductory statistics prerequisite requirement.

[**]   If STAT 22200 Linear Models and Experimental Design is used to fulfill a requirement of the Statistics minor, then STAT 22600 Analysis of Categorical Data may be used as an elective in the minor. Similarly, If STAT 22600 Analysis of Categorical Data is used to fulfill a requirement of the Statistics minor, then STAT 22200 Linear Models and Experimental Design may be used as an elective in the minor.

[***]   An approved substitute for STAT 22600 Analysis of Categorical Data is STAT 22700 Biostatistical Methods, which requires STAT 22400 Applied Regression Analysis as prerequisite and is offered by the Department of Public Health Sciences. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the Statistics minor. STAT 22700 Biostatistical Methods does not count against the limit of no more than two electives from outside the Department of Statistics.

[****] Not every combination of elective courses is allowed. Generally, no more than two electives may be satisfied by courses offered by departments other than the Department of Statistics. Students may petition the Departmental Adviser for Minors to include more than two electives from outside the Department of Statistics. Regardless, at most one elective can be satisfied by a course offered by the Booth School of Business. Further, due to the course grading policies of the Booth School of Business, their 40000-level courses cannot be counted toward the Statistics minor if taken during the quarter in which the student will graduate from the College.

DEPARTMENTAL ELECTIVES APPROVED FOR THE MINOR IN STATISTICS

STAT 11900	Introduction to Data Science II [1]	100
STAT 22000	Statistical Methods and Applications [1,2]	100
STAT 22200	Linear Models and Experimental Design [3]	100
STAT 22600	Analysis of Categorical Data [3, 4]	100
STAT 23400	Statistical Models and Methods [1]	100
STAT 24500	Statistical Theory and Methods II [5]	100
STAT 24510	Statistical Theory and Methods IIa [5]	100
STAT 26100	Time Dependent Data	100
STAT 26300	Introduction to Statistical Genetics	100
STAT 27410	Introduction to Bayesian Data Analysis	100
STAT 27815	Practical R Programming	100

[1] STAT 11900 Introduction to Data Science II and either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods, but not both, may be used as electives if taken prior to any other courses for which at least STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods is prerequisite. If either STAT 22000 Statistical Methods and Applications or STAT 23400 Statistical Models and Methods is used to fulfill a requirement for any major(s), other minors, or general education requirements, then neither course may be used to fulfill a requirement in the Statistics minor. STAT 11900 Introduction to Data Science II can only be used as an elective in the Statistics minor if the student also completes STAT 11800 Introduction to Data Science I (which cannot be included in a Statistics minor).

[2] Students may not use AP credit for STAT 22000 Statistical Methods and Applications to meet a requirement for the Statistics minor.

[3] If STAT 22200 Linear Models and Experimental Design is used to fulfill a requirement of the Statistics minor, then STAT 22600 Analysis of Categorical Data may be used as an elective in the minor. Similarly, if STAT 22600 Analysis of Categorical Data is used to fulfill a requirement of the Statistics minor, then STAT 22200 Linear Models and Experimental Design may be used as an elective in the minor.

[4] An approved substitute for STAT 22600 Analysis of Categorical Data is PBHS 32700 Biostatistical Methods (also designated as STAT 22700 Biostatistical Methods), which requires STAT 22400 Applied Regression Analysis as prerequisite and is offered by the Department of Public Health Sciences. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the Statistics minor. STAT 22700 Biostatistical Methods does not count against the limit of no more than two electives from outside the Department of Statistics.

[5] If either STAT 24500 Statistical Theory and Methods II or STAT 24510 Statistical Theory and Methods IIa is used as an elective in the Statistics minor, then the prerequisite STAT 24400 Statistical Theory and Methods I or STAT 24410 Statistical Theory and Methods Ia may not be counted toward the minor, but may be counted toward any major(s) or other minors.

NON-DEPARTMENTAL ELECTIVES APPROVED FOR THE MINOR IN STATISTICS

Because of the interdisciplinary nature of the field of statistics, other departments and committees offer courses approved for use as electives for the Statistics minor. Generally, no more than two electives may be satisfied by courses offered by departments other than the Department of Statistics. Students may petition the Departmental Adviser for Minors to include more than two electives from outside the Department of Statistics. Regardless, at most one elective can be satisfied by a course offered by the Booth School of Business. Further, due to the course grading policies of the Booth School of Business, their 40000-level courses cannot be counted toward the Statistics minor if taken during the quarter in which the student will graduate from the College.

Offering departments include Public Health Sciences, Computer Science, Comparative Human Development, Human Genetics, Public Policy, Sociology, and the Booth School of Business.

BIOS 21216	Introduction to Statistical Genetics	100
BUSN 41201	Big Data [1]	100
BUSN 41204	Machine Learning [1]	100
CHDV 30102	Introduction to Causal Inference	100
CHDV 32411	Mediation, Moderation, and Spillover Effects	100
PBHS 30910	Epidemiology and Population Health	100
PBHS 31001	Epidemiologic Methods	100
PBHS 32700	Biostatistical Methods [2]	100
PBHS 33300	Applied Longitudinal Data Analysis	100
PBHS 33400	Multilevel Modeling	100

PBHS 33500	Statistical Applications	100
PBPL 28820	Machine Learning and Policy	100
SOCI 20112	Applications of Hierarchical Linear Models	100
SOCI 20253	Introduction to Spatial Data Science	100

[1]   At most one elective can be satisfied by a course offered by the Booth School of Business. Due to the course grading policies of the Booth School of Business, their 40000-level courses cannot be counted toward the Statistics minor if taken during the quarter in which the student will graduate from the College.

[2]   An approved substitute for STAT 22600 Analysis of Categorical Data is PBHS 32700 Biostatistical Methods (also designated as STAT 22700 Biostatistical Methods), which requires STAT 22400 Applied Regression Analysis as prerequisite and is offered by the Department of Public Health Sciences. Students may count either STAT 22600 Analysis of Categorical Data or STAT 22700 Biostatistical Methods, but not both, toward the Statistics minor. STAT 22700 Biostatistical Methods does not count against the limit of no more than two electives from outside the Department of Statistics.

Some of the approved electives offered by other departments also bear a Statistics course number and some do not. Students should enroll in the relevant Department of Statistics course number when available. Examples include STAT 22700 Biostatistical Methods, STAT 22810 Epidemiology and Population Health, STAT 31900 Introduction to Causal Inference, STAT 33211 Mediation, Moderation, and Spillover Effects, STAT 35700 Epidemiologic Methods, STAT 35800 Statistical Applications, and STAT 36900 Applied Longitudinal Data Analysis.

Undergraduate registration in 30000-level and 40000-level courses is by instructor consent only. Undergraduates cannot pre-register for 30000-level or 40000-level courses. Instead, students should contact the instructor well in advance.

STATISTICS COURSES

STAT 10001. Collaborative Learning in Statistics 20000. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in STAT 20000 Elementary Statistics. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the Elementary Statistics material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the Elementary Statistics course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student's level of participation and attendance.
Instructor(s): K. Burbank Terms Offered: TBD
Prerequisite(s): Corequisite: Concurrent enrollment in STAT 20000

STAT 10118. Pathways in Data Science. 100 Units.
Learn how to glean insights and meaning from complex sets of data in this overview of a field with growing importance in business, government, and scientific research. Students will learn to use the transformational tools of data science and see how researchers are applying them in the service of social good. Working with faculty from the Department of Statistics, students will study how data is collected and stored and then how it is explored, visualized, and communicated. Using Python, students will learn techniques for classification, prediction, inference, and regression. Then, together with researchers from the University of Chicago Urban Labs, students will explore how these tools and methods can be used to inform social policy in multiple domains including poverty, health, and social mobility. Throughout the course, visiting guest lecturers will broaden students' perspectives by sharing how data science is used in their diverse fields, ranging from business applications to biology.
Terms Offered: Summer

STAT 11800-11900. Introduction to Data Science I-II.
Data science provides tools for gaining insight into specific problems using data, through computation, statistics, and visualization. These courses introduce students to all aspects of a data analysis process, from posing questions, designing data collection strategies, management+storing and processing of data, exploratory tools and visualization, statistical inference, prediction, interpretation, and communication of results. Simple techniques for data analysis are used to illustrate both effective and fallacious uses of data science tools.

STAT 11800. Introduction to Data Science I. 100 Units.
Data science provides tools for gaining insight into specific problems using data, through computation, statistics and visualization. This course introduces students to all aspects of a data analysis process, from posing questions, designing data collection strategies, management+storing and processing of data, exploratory tools and visualization, statistical inference, prediction, interpretation and communication of results. Simple techniques for data analysis are used to illustrate both effective and fallacious uses of data science tools. Although this course is designed to be at the level of mathematical sciences courses in the Core,

with little background required, we expect the students to develop computational skills that will allow them to analyze data. Computation will be done using Python and Jupyter Notebook.
Instructor(s): M.Hutch; K.Smalenberger; W. Trimble Terms Offered: Autumn Spring Winter
Equivalent Course(s): DATA 11800

STAT 11900. Introduction to Data Science II. 100 Units.
This course is the second quarter of a two-quarter systematic introduction to the foundations of data science, as well as to practical considerations in data analysis. A broad background on probability and statistical methodology will be provided. More advanced topics on data privacy and ethics, reproducibility in science, data encryption, and basic machine learning will be introduced. We will explore these concepts with real-world problems from different domains.
Instructor(s): A. Nussbaum; M. Hutch; K. Sehgal Terms Offered: Autumn Spring Winter
Prerequisite(s): DATA 11800 or consent of instructor.
Equivalent Course(s): DATA 11900

STAT 12001. Collaborative Learning in Statistics 22000. 000 Units.
This is an optional, limited enrollment workshop for students concurrently enrolled in STAT 22000 Statistical Methods and Applications. Undergraduate Team Leaders guide small groups of students in weekly workshops. The workshops focus on the analysis of problem sets designed to augment and complement the course material. Instead of tutoring or lecturing, Team Leaders coach students as they work collaboratively in small groups on the assigned problems by referencing class lectures and assigned reading materials. The workshops do not repeat but extend the substantive discussions and lectures of the course. Additionally, these workshops aim to develop communication skills, cooperative attitudes, and promote a teamwork environment. Because the benefits of collaborative learning can only be gained through consistent effort and attendance, this zero-credit course is graded P/F based on the student's level of participation and attendance.
Terms Offered: TBD
Prerequisite(s): Concurrent enrollment in STAT 22000.

STAT 12500. Quant Methods/Envir Science. 100 Units.
TBD
Equivalent Course(s): NTSC 12500

STAT 13820. Data Science in Quantitative Finance and Risk Management. 100 Units.
Have you started or are about to start your investment journey? Do you want to know more about terms like "recession" and "volatility," and how they might affect your own bank account? Are you interested in mathematics and its application to human emotions? This course introduces the leading statistical models and methods which financial data researchers use to understand ever-evolving markets and build insightful financial strategies, such as machine learning, risk calculation, and portfolio management . At first, students will learn about the theoretical and applied foundations of regression and classification designs for predicting market patterns. Next, students will gain exposure to proprietary metrics such as Value-at-Risk(VaR) used to evaluate returns/losses of both single and multi-asset portfolios. Lastly, they will experiment with portfolio allocation tactics by visualizing risk-to-reward graphs under various buying and selling conditions. These techniques can be applied to the U.S. and foreign asset classes, including equities, commodities, and cryptocurrencies. Students will experience how professionals in quantitative trading, hedge funds, and risk analytics collaborate to pitch asset strategies to their clients, and form research teams to play a stock market game using the skills they learned throughout the course with the objective of maximizing the teams' portfolio returns. All implementations will be done using Python.
Terms Offered: Summer
Equivalent Course(s): DATA 13820

STAT 20000. Elementary Statistics. 100 Units.
This course introduces statistical concepts and methods for the collection, presentation, analysis, and interpretation of data. Elements of sampling, simple techniques for analysis of means, proportions, and linear association are used to illustrate both effective and fallacious uses of statistics.
Instructor(s): Staff Terms Offered: Autumn Winter
Note(s): For students with little or no math background. Not recommended for students planning to take STAT 22000 or STAT 23400 or more advanced courses in Statistics. Students with credit for STAT 20010, STAT 22000, STAT 23400, or more advanced courses in Statistics not admitted. This course may not be used in the Statistics major or minor. This course meets one of the general education requirements in the mathematical sciences. Only one of STAT 20000, STAT 20010, or STAT 22000, can count toward the general education requirement in the mathematical sciences.

STAT 20010. Elementary Statistics Through Case Study. 100 Units.
This course uses a single real-world case study to introduce statistical concepts throughout the quarter. Topics include methods for the collection, presentation, analysis, and interpretation of data, including elements of sampling, simple techniques for analysis of means, proportions, and linear association. The case study examines the development of the water contamination crisis in Flint, Michigan, from its beginnings in 2014 to present day conditions. Students will use statistical techniques learned in the course to probe critical facets of the story including: the demographics and history of Flint; the evidence for (and uncertainty about) the existence of contamination; statistical mistakes that allowed officials to initially deny the problem; and predictions for future

health effects due to the contamination. Throughout the course, students will practice critically examining claims made in the media and in scientific publications. At the end of the quarter, students are asked to use their statistical skills to propose and defend a set of interventions to benefit the children of Flint.
Instructor(s): K. Burbank Terms Offered: TBD
Note(s): For students with little or no math background. Not recommended for students planning to take STAT 22000 or STAT 23400 or more advanced courses in Statistics. Students with credit for STAT 20000, STAT 22000, STAT 23400, or more advanced courses in Statistics not admitted. This course may not be used in the Statistics major or minor. This course meets one of the general education requirements in the mathematical sciences. Only one of STAT 20000, STAT 20010, or STAT 22000, can count toward the general education requirement in the mathematical sciences.

STAT 22000. Statistical Methods and Applications. 100 Units.
This course introduces statistical techniques and methods of data analysis including the use of statistical software. Examples are drawn from the biological, physical, and social sciences. Students are required to apply the techniques discussed to data drawn from actual research. Topics include data description, graphical techniques, exploratory data analyses, random variation and sampling, basic probability, random variables and expected values, confidence intervals, and significance tests for one- and two-sample problems for means and proportions and linear regression.
Terms Offered: Autumn Spring Winter
Prerequisite(s): MATH 13100 or 15100 or 15200 or 15300 or 16100 or 16110 or 15910 or 18300 or 19520 or 19620 or 20250 or 20300 or 20310.
Note(s): Students may count either STAT 22000 or STAT 23400, but not both, toward the forty-two credits required for graduation. Students with credit for STAT 23400 not admitted. This course meets on of the general education requirements in the mathematical sciences. Only one of STAT 20000, STAT 20010, or STAT 22000, can count toward the general education requirement in the mathematical sciences.

STAT 22200. Linear Models and Experimental Design. 100 Units.
This course covers principles and techniques for the analysis of experimental data and the planning of the statistical aspects of experiments. Topics include linear models; analysis of variance; randomization, blocking, and factorial designs; confounding; and incorporation of covariate information.
Instructor(s): Staff Terms Offered: Spring
Prerequisite(s): [STAT 22000 or 23400 or (STAT 11800 & 11900) or ECON 11010 or BUSN 41000 grade at least C +, or STAT 22400 or 22600 or 24500 or 24510 or PBHS 32100, or APStat credit STAT 22000] & [2 qtrs of calculus (MATH 13200 or 15200 or 15300 or 16200 or 16210 or 15910 or 18300 or 19520 or 19620 or 20250 or 20300 or 20310)]

STAT 22400. Applied Regression Analysis. 100 Units.
This course introduces the methods and applications of fitting and interpreting multiple regression models. The primary emphasis is on the method of least squares and its many varieties. Topics include the examination of residuals, the transformation of data, strategies and criteria for the selection of a regression equation, the use of dummy variables, tests of fit, nonlinear models, biases due to excluded variables and measurement error, and the use and interpretation of computer package regression programs. The techniques discussed are illustrated by many real examples involving data from both the natural and social sciences. Matrix notation is introduced as needed. Prerequisite: PBHS 32100. Equivalent Course(s): PBHS 32400
Terms Offered: Autumn Spring
Prerequisite(s): [STAT 22000 or 23400 or (STAT 11800 & 11900) or ECON 11010 or BUSN 41000 with a grade of at least C+, or STAT 22200 or 22600 or 24500 or 24510 or PBHS 32100, or AP Statistics credit for STAT 22000], and [MATH 13200/15200/15300/16200/16210/15910/18300/19520/19620/20250/20300 and 20310].
Note(s): Students may count either STAT 22400 or STAT 22401, but not both, toward the forty-two credits required for graduation.
Equivalent Course(s): PBHS 32400

STAT 22401. Regression Analysis for Health and Social Research. 100 Units.
This course is an introduction to the methods and applications of fitting and interpreting multiple regression models. The main emphasis is on the method of least squares. Topics include the examination of residuals, the transformation of data, strategies and criteria for the selection of a regression equation, the use of dummy variables, tests of fit. Stata computer package will be used extensively, but previous familiarity with Stata is not assumed. The techniques discussed will be illustrated by real examples involving health and social science data.
Instructor(s): James Dignam Terms Offered: Winter
Prerequisite(s): PBHS 32100 or STAT 22000 or equivalent
Equivalent Course(s): PBHS 32410

STAT 22600. Analysis of Categorical Data. 100 Units.
This course covers statistical methods for the analysis of qualitative and counted data. Topics include description and inference for binomial and multinomial data using proportions and odds ratios; multi-way contingency tables; generalized linear models for discrete data; logistic regression for binary responses; multi-category logit models for nominal and ordinal responses; loglinear models for counted data; and inference for matched-pairs and correlated data. Applications and interpretations of statistical models are emphasized.
Terms Offered: Winter

Prerequisite(s): [STAT 22000 or 23400 or (STAT 11800 & 11900) or ECON 11010 or BUSN 41000 grade at least C +, or STAT 22400 or 22600 or 24500 or 24510 or PBHS 32100, or APStat credit STAT 22000] & [2 qtrs of calculus (MATH 13200 or 15200 or 15300 or 16200 or 16210 or 15910 or 18300 or 19520 or 19620 or 20250 or 20300 or 20310)]
Equivalent Course(s): PBHS 32600

STAT 22700. Biostatistical Methods. 100 Units.
This course is designed to provide students with tools for analyzing categorical, count, and time-to-event data frequently encountered in medicine, public health, and related biological and social sciences. This course emphasizes application of the methodology rather than statistical theory (e.g., recognition of the appropriate methods; interpretation and presentation of results). Methods covered include contingency table analysis, Kaplan-Meier survival analysis, Cox proportional-hazards survival analysis, logistic regression, and Poisson regression.
Instructor(s): L. Chen Terms Offered: Spring
Prerequisite(s): PBHS 32400 or PBHS 32410 or STAT 22400 or STAT 24500 or equivalent.
Equivalent Course(s): PBHS 32700

STAT 22810. Epidemiology and Population Health. 100 Units.
Epidemiology is the basic science of public health. It is the study of how diseases are distributed across populations and how one designs population-based studies to learn about disease causes, with the object of identifying preventive strategies. Epidemiology is a quantitative field and draws on biostatistical methods. Historically, epidemiology's roots were in the investigation of infectious disease outbreaks and epidemics. Since the mid-twentieth century, the scope of epidemiologic investigations has expanded to a fuller range non-infectious diseases and health problems. This course will introduce classic studies, study designs and analytic methods, with a focus on global health problems.
Instructor(s): D. Lauderdale Terms Offered: Autumn
Prerequisite(s): STAT 22000 or other introductory statistics highly desirable. For BIOS students-completion of the first three quarters of a Biological Sciences Fundamentals sequence.
Equivalent Course(s): PPHA 36410, PBHS 30910, BIOS 27810, HLTH 20910

STAT 23400. Statistical Models and Methods. 100 Units.
This course is recommended for students throughout the natural and social sciences who want a broad background in statistical methodology and exposure to probability models and the statistical concepts underlying the methodology. Probability is developed for the purpose of modeling outcomes of random phenomena. Random variables and their expectations are studied including means and variances of linear combinations and an introduction to conditional expectation. Binomial, Poisson, normal, and other standard probability distributions are considered. Some probability models are studied mathematically, and others are studied via computer simulation. Sampling distributions and related statistical methods are explored mathematically, studied via simulation, and illustrated on data. Methods include, but are not limited to, inference for means and proportions for one- and two-sample problems, two-way tables, correlation, and simple linear regression. Graphical and numerical data description are used for exploration, communication of results, and comparing mathematical consequences of probability models and data. Mathematics employed is to the level of single-variable differential and integral calculus and sequences and series.
Terms Offered: Autumn Spring Winter
Prerequisite(s): MATH 13300 or 15300 or 16200 or 16210 or 15910 or 18300 or 19520 or 19620 or 20250 or 20300 or 20310.
Note(s): Students may count either STAT 22000 or STAT 23400, but not both, toward the forty-two credits required for graduation. Students with AP Statistics credit for STAT 22000 will forego that credit by completing STAT 23400.

STAT 24300. Numerical Linear Algebra. 100 Units.
This course is devoted to the basic theory of linear algebra and its significant applications in scientific computing. The objective is to introduce students to the tools needed to state, analyze, and solve multivariate problems. Students should leave the course ready to use linear algebra in future courses in algorithms, scientific computing, mathematical modeling, signal processing, multivariate statistics, data analysis, as well as the physical and social sciences. Topics include Gaussian elimination, vector spaces, linear transformations and associated fundamental subspaces, orthogonality and projections, eigenvectors and eigenvalues, diagonalization of real symmetric and complex Hermitian matrices, the spectral theorem, and matrix decompositions (QR, and Singular Value Decompositions). Systematic methods applicable in high dimensions and techniques commonly used in scientific computing are emphasized. Students enrolled in the graduate level STAT 30750 will have additional work in assignments, exams, and projects including applications of matrix algebra in statistics and numerical computations implemented in Matlab or R. Some programming exercises will appear as optional work for students enrolled in the undergraduate level STAT 24300.
Terms Offered: Autumn Winter
Prerequisite(s): MATH 16300 or MATH 16310 or MATH 18300 or MATH 19620 or MATH 20300 or MATH 20310 or MATH 20320. Or graduate student in Statistics or Financial Mathematics.

STAT 24310. Numerical Linear Algebra: An Introduction to Computation. 100 Units.
Computation is an essential topic across the physical and social sciences, in statistics, data science, and machine learning. Numerical linear algebra is the essential language of computation. Through a series of hands-on applications, students will implement and evaluate the essential algorithms used to solve linear systems and least squares problems, perform regression, orthogonalize bases, decompose signals via the FFT and related transforms, and perform matrix factorizations. We will focus on the computational complexity and stability of each algorithm, as well as its practical uses. Example applications include iterative optimizers used to solve large systems arising in engineering, spectral embedding methods for dimension reduction (PCA, MDS, and diffusion maps), and linear methods for classification and clustering. Examples will be presented as interactive coding notebooks available through a web browser. Prior coding experience is strongly encouraged, though students looking for an introduction to Jupyter notebooks and Python are welcome to enroll.
Terms Offered: Spring
Prerequisite(s): STAT 24300 or an equivalent introductory linear algebra class. Coding experience in Python, Matlab, R, or Julia is strongly recommended.
Equivalent Course(s): CAAM 24310

STAT 24320. Applications in Numerical Linear Algebra. 100 Units.
This course delves into the practical applications of methods in numerical linear algebra. Students will see how material first introduced in STAT 24300 can be applied to problems in data analysis, dynamical systems, and statistics. Topics will include projection and orthogonality for optimization in linear systems; spectral methods for discrete time dynamical systems and sampling algorithms including Markov Chain Monte Carlo; and matrix decompositions such as QR and SVD for dimensionality reduction techniques including PCA and others. For each topic, students will have multiple opportunities to apply the methods to real data sets. While this course will not emphasize programming, some familiarity with Python or Julia is encouraged.
Terms Offered: Spring
Prerequisite(s): STAT 24300 or an equivalent introductory linear algebra class. Coding experience in Python, Matlab, R, or Julia is recommended.

STAT 24400-24500. Statistical Theory and Methods I-II.
This sequence is a systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data.

STAT 24400. Statistical Theory and Methods I. 100 Units.
This course is the first quarter of a two-quarter systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data. This course covers tools from probability and the elements of statistical theory. Topics include the definitions of probability and random variables, binomial and other discrete probability distributions, normal and other continuous probability distributions, joint probability distributions and the transformation of random variables, principles of inference (including Bayesian inference), maximum likelihood estimation, hypothesis testing and confidence intervals, likelihood ratio tests, multinomial distributions, and chi-square tests. Examples are drawn from the social, physical, and biological sciences. The coverage of topics in probability is limited and brief, so students who have taken a course in probability find reinforcement rather than redundancy. Students who have already taken STAT 25100 have the option to take STAT 24410 (if offered) instead of STAT 24400.
Instructor(s): Staff Terms Offered: Autumn Winter
Prerequisite(s): MATH 18400/19520/20000 w/ B or better, or MATH 16300/16310/20250 or MATH 20300 or 20310 or 20700 w/ C+ or better, or (MATH 15250 and MATH 15300, both w/ B or better) or enrolled in MATH 16300/16310/18400/19520/20000/20250/20300/20310/20700 during preregistration. Or instructor consent.
Note(s): Some previous experience with statistics and/or probability helpful but not required. Concurrent or prior linear algebra (MATH 18600 or 19620 or 20250 or STAT 24300 or equivalent) is recommended for students continuing to STAT 24500. Students may count either STAT 24400 or STAT 24410, but not both, toward the forty-two credits required for graduation.

STAT 24500. Statistical Theory and Methods II. 100 Units.
This course is the second quarter of a two-quarter systematic introduction to the principles and techniques of statistics, as well as to practical considerations in the analysis of data, with emphasis on the analysis of experimental data. This course continues from either STAT 24400 or STAT 24410 and covers statistical methodology, including the analysis of variance, regression, correlation, and some multivariate analysis. Some principles of data analysis are introduced, and an attempt is made to present the analysis of variance and regression in a unified framework. Statistical software is used.
Instructor(s): Staff Terms Offered: Spring Winter
Prerequisite(s): Linear algebra (MATH 18600 or 19620 or 20250 or MATH 20700 or STAT 24300 or equivalent) and (STAT 24400 or STAT 24410).
Note(s): Students may count either STAT 24500 or STAT 24510, but not both, toward the forty-two credits required for graduation.

STAT 24410-24510. Statistical Theory and Methods Ia-IIa.

This sequence provides a sophisticated introduction to statistical principles and methods and their application to the analysis of data. In addition to serving undergraduates with a strong interest in Statistics, it is the recommended sequence in theoretical statistics for MS students in Statistics.

STAT 24410. Statistical Theory and Methods Ia. 100 Units.

This course is the first quarter of a two-quarter sequence providing a principled development of statistical methods, including practical considerations in applying these methods to the analysis of data. The course begins with a brief review of probability and some elementary stochastic processes, such as Poisson processes, that are relevant to statistical applications. The bulk of the quarter covers principles of statistical inference from both frequentist and Bayesian points of view. Specific topics include maximum likelihood estimation, posterior distributions, confidence and credible intervals, principles of hypothesis testing, likelihood ratio tests, multinomial distributions, and chi-square tests. Additional topics may include diagnostic plots, bootstrapping, a critical comparison of Bayesian and frequentist inference, and the role of conditioning in statistical inference. Examples are drawn from the social, physical, and biological sciences. The statistical software package R will be used to analyze datasets from these fields and instruction in the use of R is part of the course.
Instructor(s): Staff Terms Offered: Autumn
Prerequisite(s): STAT 25100 or STAT 25150 or MATH 23500. This course is only open to graduate students in Statistics, Applied Mathematics, and Financial Mathematics, and to undergraduate Statistics majors, or by consent of instructor.
Note(s): Some previous experience with statistics helpful but not required. Concurrent or prior linear algebra (MATH 18600 or 19620 or 20250 or 20700 or STAT 24300 or equivalent) is recommended for students continuing to STAT 24510. Students may count either STAT 24400 or STAT 24410, but not both, toward the forty-two credits required for graduation.
Equivalent Course(s): STAT 30030

STAT 24510. Statistical Theory and Methods IIa. 100 Units.

This course is a continuation of STAT 24410. The focus is on theory and practice of linear models, including the analysis of variance, regression, correlation, and some multivariate analysis. Additional topics may include bootstrapping for regression models, nonparametric regression, and regression models with correlated errors.
Terms Offered: Winter
Prerequisite(s): STAT 24410 and linear algebra (MATH 18600 or 19620 or 20250 or 20700 or STAT 24300 or equivalent). This course is only open to graduate students in Statistics, Applied Mathematics, and Financial Mathematics, and to undergraduate Statistics majors, or by consent of instructor.
Note(s): Students may count either STAT 24500 or STAT 24510, but not both, toward the forty-two credits required for graduation.
Equivalent Course(s): STAT 30040

STAT 24620. Multivariate Statistical Analysis: Applications and Techniques. 100 Units.

This course focuses on applications and techniques for analysis of multivariate and high dimensional data. Beginning subjects cover common multivariate techniques and dimension reduction, including principal component analysis, factor model, canonical correlation, multi-dimensional scaling, discriminant analysis, clustering, and correspondence analysis (if time permits). Further topics on statistical learning for high dimensional data and complex structures include penalized regression models (LASSO, ridge, elastic net), sparse PCA, independent component analysis, Gaussian mixture model, Expectation-Maximization methods, and random forest. Theoretical derivations will be presented with emphasis on motivations, applications, and hands-on data analysis.
Instructor(s): M. Wang Terms Offered: Spring
Prerequisite(s): (STAT 24300 or MATH 20250) and (STAT 24500 or STAT 24510). Graduate students in Statistics or Financial Mathematics can enroll without prerequisites.
Note(s): Linear algebra at the level of STAT 24300. Knowledge of probability and statistical estimation techniques (e.g. maximum likelihood and linear regression) at the level of STAT 24400-24500.
Equivalent Course(s): FINM 34700, STAT 32950

STAT 24630. Causal Inference Methods and Case Studies. 100 Units.

In many applications of statistics, a large proportion of the questions of interest are about causality rather than questions of description or association. Would booster shots reduce the chance of getting infected by the new variant of COVID-19? How does a new tax policy affect the economic activity? Can a universal health insurance program improve people's health? In this class, we will introduce some basic concepts and methods in causal inference and discuss examples from various disciplines. The course plans to cover the potential outcome framework, randomize experiments, randomization and model-based inference, matching, sensitivity analysis, and instrumental variables. Examples include the evaluation of job training programs, educational voucher schemes, clinical trials and observational data of medical treatments, smoking, the influenza vaccination study, and more.
Terms Offered: TBD
Prerequisite(s): (STAT 23400 + (STAT 25100 or STAT 25150)) or (STAT 24400 or STAT 24410)

STAT 25100. Introduction to Mathematical Probability. 100 Units.
This course covers fundamentals and axioms; combinatorial probability; conditional probability and independence; binomial, Poisson, and normal distributions; the law of large numbers and the central limit theorem; and random variables and generating functions.
Instructor(s): Staff Terms Offered: TBD
Prerequisite(s): ((MATH 16300 or MATH 16310 or MATH 20300 or MATH 20310 or MATH 20700), with no grade requirement), or ((MATH 18400 or (MATH 15250 and 15300)) with (either a minimum grade of B-, or a Statistics major, or currently enrolled in prerequisite course during preregistration)). Or instructor consent.
Note(s): Students may count either STAT 25100 or STAT 25150, but not both, toward the forty-two credits required for graduation.

STAT 25150. Introduction to Mathematical Probability-A. 100 Units.
This course covers combinatorics; basic notions of probability and conditional probability; independence; expectation, variance, and covariance; discrete and continuous random variables, including distributions such as binomial, normal, multinomial, geometric, hypergeometric, negative binomial, and Poisson; Gambler's Ruin; generating functions and applications to branching processes; the (Weak) Law of Large Numbers and its application to approximation by polynomials, i.e., the Weierstrass Approximation Theorem; random walk, including proof of recurrence in one and two dimensions and transience in three dimensions; characteristic functions and the Central Limit Theorem.
Instructor(s): Robert Fefferman Terms Offered: TBD. To be determined
Prerequisite(s): (MATH 16300 or MATH 16310 or MATH 20500 or MATH 20510, with a minimum grade of A-), or (MATH 20900 with no grade requirement), or consent of instructor.
Note(s): Students may count either STAT 25100 or STAT 25150, but not both, toward the forty-two credits required for graduation.

STAT 25211. Introduction to Random Matrices. 100 Units.
The course is an introduction to the random matrix theory. We will study the asymptotic properties of various random matrix models (Wigner matrices, Gaussian ensembles, etc.). We will also discuss some applications to statistics and neural networks.
Terms Offered: TBD
Prerequisite(s): (STAT 25100 or STAT 25150 or MATH 23500) and (MATH 18600 or MATH 19620 or STAT 24300 or MATH 20250 or MATH 20700), or consent of instructor.

STAT 25250. Fundamentals of Probability in Statistical Inference. 100 Units.
This course provides the necessary probabilistic foundation for tackling statistical problems and explores how these concepts can be applied to real-world data. Beginning with an introduction to probability and statistical inference, the course develops a framework for understanding convergence of probability measures, including convergence in distribution, probability, and almost sure convergence. We examine the Law of Large Numbers and the Central Limit Theorem, emphasizing their importance in statistical inference and real-world applications. Markov Chains are introduced with a focus on their recurrence, transience, and ergodicity, along with their applications in sampling techniques like Markov Chain Monte Carlo and simulated annealing. Methods for parameter estimation are explored in depth. The efficiency and asymptotic properties of estimators are discussed using tools such as the Cramer-Rao bound. Hypothesis testing methods, including Wald tests, t-tests, and goodness-of-fit tests, are studied in detail, with particular emphasis on their asymptotic consistency and power analysis. Bayesian approaches, such as prior and posterior distributions, Bayesian confidence regions, and the Bernstein-von Mises Theorem, are also covered. The course concludes with problems in regression methods, including linear models, least-squares estimation, inference, and a brief exploration of high-dimensional linear regression.
Instructor(s): P. Ghosal Terms Offered: Winter
Prerequisite(s): STAT 25100 and STAT 24400.
Note(s): Throughout the course, real data examples will be used to demonstrate the practical applications of these probabilistic and statistical concepts. This course is ideal for students seeking a solid probabilistic foundation for statistical problems analysis, with a focus on practical insights and the theoretical rigor of asymptotic properties. A working knowledge of probability concepts, including expectation, variance, and various distributions, is required. A foundational understanding of linear algebra, including proficiency with vectors, matrices, and eigenvalues, is highly recommended.

STAT 25300. Introduction to Probability Models. 100 Units.
This course introduces stochastic processes as models for a variety of phenomena in the physical and biological sciences. Following a brief review of basic concepts in probability, we introduce stochastic processes that are popular in applications in sciences (e.g., discrete time Markov chain, the Poisson process, continuous time Markov process, renewal process and Brownian motion).
Instructor(s): Staff Terms Offered: Winter
Prerequisite(s): STAT 24400 or STAT 24410 or STAT 25100 or STAT 25150
Equivalent Course(s): STAT 31700

STAT 26100. Time Dependent Data. 100 Units.
This course considers the modeling and analysis of data that are ordered in time. The main focus is on quantitative observations taken at evenly spaced intervals and includes both time-domain and spectral approaches.
Instructor(s): W. Wu Terms Offered: Autumn
Prerequisite(s): STAT 24500 w/B- or better or STAT 24510 w/C+ or better is required; alternatively STAT 22400 w/B- or better and exposure to multivariate calculus (MATH 16300 or MATH 16310 or MATH 18400 or MATH 19520 or MATH 20000 or MATH 20500 or MATH 20510 or MATH 20800). Graduate students in Statistics or Financial Mathematics can enroll without prerequisites. Some previous exposure to Fourier series is helpful but not required.
Equivalent Course(s): STAT 33600

STAT 26300. Introduction to Statistical Genetics. 100 Units.
As a result of technological advances over the past few decades, there is a tremendous wealth of genetic data currently being collected. These data have the potential to shed light on the genetic factors influencing traits and diseases, as well as on questions of ancestry and population history. The aim of this course is to develop a thorough understanding of probabilistic models and statistical theory and methods underlying analysis of genetic data, focusing on problems in complex trait mapping, with some coverage of population genetics. Although the case studies are all in the area of statistical genetics, the statistical inference topics, which will include likelihood-based inference, linear mixed models, and restricted maximum likelihood, among others, are widely applicable to other areas. No biological background is needed, but a strong foundation in linear algebra, as well as probability and statistics at the level of STAT 24400-STAT 24500 or higher is assumed.
Instructor(s): M. McPeek Terms Offered: Spring
Prerequisite(s): STAT 24500 or 24510 or 30200 or consent of instructor.
Equivalent Course(s): STAT 35490

STAT 26700. History of Statistics. 100 Units.
This course covers topics in the history of statistics, from the eleventh century to the middle of the twentieth century. We focus on the period from 1650 to 1950, with an emphasis on the mathematical developments in the theory of probability and how they came to be used in the sciences. Our goals are both to quantify uncertainty in observational data and to develop a conceptual framework for scientific theories. This course includes broad views of the development of the subject and closer looks at specific people and investigations, including reanalyses of historical data.
Instructor(s): S. Stigler Terms Offered: TBD. Not offered in 2024-2025.
Prerequisite(s): Prior statistics course
Equivalent Course(s): STAT 36700, CHSS 32900, HIPS 25600

STAT 27400. Nonparametric Inference. 100 Units.
Nonparametric inference is about developing statistical methods and models that make weak assumptions. A typical nonparametric approach estimates a nonlinear function from an infinite dimensional space rather than a linear model from a finite dimensional space. This course gives an introduction to nonparametric inference, with a focus on density estimation, regression, confidence sets, orthogonal functions, random processes, and kernels. The course treats nonparametric methodology and its use, together with theory that explains the statistical properties of the methods.
Instructor(s): Staff Terms Offered: Winter
Prerequisite(s): STAT 24400 or STAT 24410 w/B- or better is required; alternatively STAT 22400 w/B+ or better and exposure to multivariate calculus (MATH 16300 or MATH 16310 or MATH 18400 or MATH 19520 or MATH 20000 or MATH 20500 or MATH 20510 or MATH 20800) and linear algebra (MATH 18600 or 19620 or 20250 or 20700 or STAT 24300 or equivalent). Master's students in Statistics can enroll without prerequisites.
Equivalent Course(s): STAT 37400, DATA 37400

STAT 27410. Introduction to Bayesian Data Analysis. 100 Units.
In recent years, Bayes and empirical Bayes (EB) methods have continued to increase in popularity and impact. These methods, combining information from similar and independent experiments and yield improved estimation of both individual and shared model characteristics, have been widely applied in many fields such as biomedical science, public health, epidemiology, education, social science, ecomnomics, psychology, agriculture and engineering. In this course, we will introduce Bayes and EB methods, as well as the necessary tools needed to evaluate their performances comparing with the frequentist methods. For computation, we will introduce Markov chain Monte Carlo methods such as the Gibbs sampler algorithm. We will use R and RStan to implement these methods and solve real world problems. Students in this class are required to do final projects in small groups. During the last week of the quarter, each group will have the opportunity to present the final project to the class. Final reports based on the group projects will be due by the end of the exam week. Due to the attention required from the instructor to supervise the final projects, the class size will be capped at the enrollment limit.
Terms Offered: TBD
Prerequisite(s): (STAT 23400 or 24400 or 24410) and (STAT 22400 or 22600 or 24500 or 24510)
Note(s): Coding in R will be heavily involved in this class.

STAT 27420. Introduction to Causality with Machine Learning. 100 Units.
This course is an introduction to causal inference. We'll cover the core ideas of causal inference and what distinguishes it from traditional observational modeling. This includes an introduction to some foundational ideas---structural equation models, causal directed acyclic graphs, and then do calculus. The course has a particular emphasis on the estimation of causal effects using machine learning methods.
Instructor(s): V. Veitch Terms Offered: TBD
Prerequisite(s): [STAT 24500 or STAT 24510 or STAT 27725] with a grade of B or higher or consent of instructor.
Equivalent Course(s): DATA 27420

STAT 27700. Mathematical Foundations of Machine Learning. 100 Units.
This course is an introduction to the mathematical foundations of machine learning that focuses on matrix methods and features real-world applications ranging from classification and clustering to denoising and data analysis. Mathematical topics covered include linear equations, regression, regularization, the singular value decomposition, and iterative algorithms. Machine learning topics include classification and regression, support vector machines, kernel methods, clustering, matrix completion, neural networks, and deep learning. Students are expected to have taken calculus and have exposure to numerical computing (e.g. Matlab, Python, Julia, R).
Prerequisite(s): CMSC 11900 or CMSC 12200 or CMSC 14100 or CMSC 15200 or CMSC 16200
Note(s): Undergraduate students are not allowed to enroll in CMSC 35300.
Equivalent Course(s): CMSC 35300, CMSC 25300

STAT 27725. Machine Learning. 100 Units.
This course introduces the foundations of machine learning and provides a systematic view of a range of machine learning algorithms. Topics covered include two parts: (1) a gentle introduction of machine learning: generalization and model selection, regression and classification, kernels, neural networks, clustering and dimensionality reduction; (2) a statistical perspective of machine learning, where we will dive into several probabilistic supervised and unsupervised models, including logistic regression, Gaussian mixture models, and generative adversarial networks.
Prerequisite(s): CMSC 25300 or CMSC 35300 or STAT 24300 or STAT 24500 or ((MATH 18600 or MATH 20250) and (CMSC 12100 or CMSC 14100 or CMSC 15100 or CMSC 16100) and (STAT 25100 or STAT 25150))
Equivalent Course(s): CMSC 25400

STAT 27750. Further Topics in Machine Learning. 100 Units.
This is an intermediate-to-advanced course in machine learning. You should have taken at least one course in machine learning before and be familiar with both theoretical foundations---(empirical) risk minimization and friends---as well as having some practical experience fitting machine learning models to data. The intended material covered by the course is boosting, (fine-tuning of) neural networks, model evaluation, and domain shifts.
Instructor(s): V. Veitch Terms Offered: TBD
Prerequisite(s): STAT 24500 or STAT 24510 or [STAT 27725 with a grade of B or higher]

STAT 27751. Trustworthy Machine Learning. 100 Units.
Machine learning systems are routinely used in safety critical situations in the real world. However, they often dramatically fail! This course covers foundational and practical concerns in building machine learning systems that can be trusted. Topics include foundational issues---when do systems generalize, and why, essential results in fairness and domain shifts, and evaluations beyond standard test/train splits. This is an intermediate level course in machine learning; students should have at least one previous course in machine learning.
Terms Offered: TBD
Prerequisite(s): STAT 27700 or STAT 37710 or consent of instructor.
Equivalent Course(s): DATA 27751, STAT 37787

STAT 27815. Practical R Programming. 100 Units.
This course covers a practical set of skills vital to modern statistics and data science in handling messy, real-world data. Throughout the course, students will practice reproducible research with version control and literate programming. They will think algorithmically with base R objects, control flow, functions, and iteration. Students will also be introduced to a variety of tidyverse data wrangling methods to import, clean, transform, join, and summarize their data. Finally, students will visualize and explore data using the grammar of graphics framework. Additional introductory topics may be discussed. No programming experience is required, although some will be helpful. Credit may not be earned for both STAT 27815 and STAT 37815.
Instructor(s): R. McShane Terms Offered: TBD
Prerequisite(s): STAT 22000 or 22200 or 22400 or 22600 or 23400 or 24410 or 24500 or 24510 or 34300 or consent of instructor.

STAT 27850. Multiple Testing, Modern Inference, and Replicability. 100 Units.
This course examines the problems of multiple testing and statistical inference from a modern point of view. High-dimensional data is now common in many applications across the biological, physical, and social sciences. With this increased capacity to generate and analyze data, classical statistical methods may no longer ensure the reliability or replicability of scientific discoveries. We will examine a range of modern methods that provide statistical inference tools in the context of modern large-scale data analysis. The course will have weekly assignments as well as a final project, both of which will include both theoretical and computational components.
Terms Offered: TBD

Prerequisite(s): STAT 24400 or STAT 24410. Familiarity with regression and with coding in R are recommended.
Equivalent Course(s): STAT 30850

STAT 27855. Hypothesis Testing with Empirical Bayes Methodology. 100 Units.
Large scale data sets regularly produced in fields such as biology, social sciences, and neuroscience bring new challenges, like controlling the amount of false positives when testing many hypotheses, as well as the opportunity to leverage information across the entire dataset toward making individual inferences. In this course, we will study theoretical foundations and practical aspects of hypothesis testing in a Bayesian framework. We will focus attention on the local false discovery rate (lfdr), which represents the probability that the null hypothesis is true given the data, and learn several methods for estimating this quantity. Decision theory provides a formal connection between quantities of interest in a Bayesian framework to population parameters in a strictly frequentist model, where the truth status of each null hypothesis is fixed and unknown. We may also discuss methodology for estimating the null distribution, and methods for finite-sample lfdr control if time permits. Homework assignments will have theoretical and computational components.
Instructor(s): D. Xiang Terms Offered: Winter
Prerequisite(s): STAT 24400 or STAT 24410 or consent of instructor

STAT 28000. Optimization. 100 Units.
This is an introductory course on optimization that will cover the rudiments of unconstrained and constrained optimization of a real-valued multivariate function. The focus is on the settings where this function is, respectively, linear, quadratic, convex, or differentiable. Time permitting, topics such as nonsmooth, integer, vector, and dynamic optimization may be briefly addressed. Materials will include basic duality theory, optimality conditions, and intractability results, as well as algorithms and applications.
Instructor(s): L. Lim Terms Offered: Spring
Prerequisite(s): (MATH 20500 or MATH 20510 or MATH 20520 or MATH 20800) and (STAT 24300 or MATH 20250 or MATH 20700)
Equivalent Course(s): CAAM 28000

STAT 28200. Dynamical Systems with Applications. 100 Units.
This course is concerned with the analysis of nonlinear dynamical systems arising in the context of mathematical modeling. The focus is on qualitative analysis of solutions as trajectories in phase space, including the role of invariant manifolds as organizers of behavior. Local and global bifurcations, which occur as system parameters change, will be highlighted, along with other dimension reduction methods that arise when there is a natural time-scale separation. Concepts of bi-stability, spontaneous oscillations, and chaotic dynamics will be explored through investigation of conceptual mathematical models arising in the physical and biological sciences.
Instructor(s): Mary Silber Terms Offered: TBD
Prerequisite(s): MATH 27300 or (Multivariable calculus (MATH 18400 or 19520 or 20000 or 20400 or 20410 or PHYS 22100 or equivalent), AND linear algebra, including eigenvalues & eigenvectors (MATH 18600 or 19620 or 20250 or 20700 or STAT 24300)). Previous knowledge of elementary differential equations is helpful but not required.
Equivalent Course(s): CAAM 31405, STAT 31405, CAAM 28200

STAT 29700. Undergraduate Research. 100 Units.
This course consists of reading and research in an area of statistics or probability under the guidance of a faculty member in the Department of Statistics.
Instructor(s): Staff Terms Offered: Autumn Spring Winter
Prerequisite(s): Consent of faculty adviser and Departmental Adviser for Majors
Note(s): Students are required to submit the College Reading and Research Course Form. Open to all students, including non-majors. Ordinarily taken for P/F grading, but under certain circumstances may be be taken for a quality grade by petition.

STAT 29900. Bachelor's Paper. 100 Units.
This course consists of reading and research in an area of statistics or probability under the guidance of a faculty member in the Department of Statistics, leading to a bachelor's paper. A good draft of the paper must be submitted by the first day of exam period.
Terms Offered: Autumn Spring Winter
Prerequisite(s): Consent of faculty adviser and Departmental Adviser for Majors
Note(s): Students are required to submit the College Reading and Research Course Form. Open only to students who are majoring in Statistics. Grading is P/F only.

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