Statistics


The department’s goals are to acquaint students with the role played in science and technology by probabilistic and statistical ideas and methods, to provide instruction in the theory and application of techniques that have been found to be commonly useful, and to train research workers in probability and statistics. There are courses for general students as well as those who plan careers in statistics in business, government, industry, and teaching.

The requirements for a degree in Statistics are flexible, depending on the needs and interests of the students. Some students may be interested in the theory of statistics and/or probability, whereas other students may wish to apply statistical and probabilistic methods to a substantive area. The department has long recognized the relation of statistical theory to applications. It has fostered this by encouraging a liaison with other departments in the form of joint and courtesy faculty appointments: Economics (Anderson, Romano), Education (Olkin, Rogosa), Electrical Engineering (Montanari), Geological and Environmental Sciences (Rajaratnam, Switzer), Health Research and Policy (Efron, Hastie, Johnstone, Lavori, Olshen, Tibshirani, Wong), Mathematics (Candes, Dembo, Diaconis), Political Science (Jackman), and the SLAC National Accelerator Laboratory (Friedman). The research activities of the department reflect an interest in applied and theoretical statistics and probability. There are workshops in biology/medicine and in environmental factors in health.

In addition to courses for Statistics students, the department offers a number of service courses designed for students in other departments. These tend to emphasize the application of statistical techniques rather than their theoretical development.

The department has always drawn visitors from other countries and universities. As a consequence, there is usually a wide range of seminars offered by both the visitors and the department’s own faculty.

Undergraduate Programs in Statistics

Majoring in Statistics

Students wishing to build a concentration in probability and statistics are encouraged to consider declaring a major in Mathematical and Computational Science (http://www.stanford.edu/group/mathcompsci). This interdepartmental program is administered in the Department of Statistics and provides core training in computing, mathematics, operations research, and statistics, with opportunities for further elective work and specialization. See the "Mathematical and Computational Science" section of this bulletin.

Graduate Programs in Statistics

University requirements for the M.S. and Ph.D. degrees are discussed in the "Graduate Degrees (http://exploredegrees.stanford.edu/archive/2012-13/graduatedegrees) " section of this bulletin.

Learning Outcomes (Graduate)

The purpose of the master’s program is to further develop knowledge and skills in Statistics and to prepare students for a professional career or doctoral studies. This is achieved through completion of courses, in the primary field as well as related areas, and experience with independent work and specialization.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research and analysis in Statistics. Through completion of advanced course work and rigorous skills training, the doctoral program prepares students to make original contributions to the knowledge of Statistics and to interpret and present the results of such research.

Minor in Statistics

The undergraduate minor in Statistics is designed to complement major degree programs primarily in the social and natural sciences. Students with an undergraduate Statistics minor should find broadened possibilities for employment. The Statistics minor provides valued preparation for professional degree studies in postgraduate academic programs.

The minor consists of a minimum of six courses with a total of at least 20 units. There are two required courses (8 units) and four qualifying or elective courses (12 or more units). All courses for the minor must be letter graded. An overall 2.75 grade point average (GPA) is required for courses fulfilling the minor.

Required Courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 116</td>
<td>Theory of Probability</td>
<td>3-5</td>
</tr>
<tr>
<td>STATS 200</td>
<td>Introduction to Statistical Inference</td>
<td>3</td>
</tr>
</tbody>
</table>

Qualifying Courses

At most, one of these two courses may be counted toward the six course requirement for the minor:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 52</td>
<td>Integral Calculus of Several Variables</td>
<td>5</td>
</tr>
<tr>
<td>STATS 191</td>
<td>Introduction to Applied Statistics</td>
<td>3-4</td>
</tr>
</tbody>
</table>

Elective Courses

At least one of the elective courses should be a STATS 200-level course. The remaining two elective courses may also be 200-level courses. Alternatively, one or two elective courses may be approved courses in other departments. Special topics courses and seminars for undergraduates are offered from time to time by the department, and these may be counted toward the course requirement. Students may not count any Statistics courses below the 100 level toward the minor. Examples of elective course sequences are:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Examples of elective course sequences are:</td>
<td></td>
</tr>
</tbody>
</table>
Master of Science in Statistics

The department requires that the student take 45 units of work from offerings in the Department of Statistics (http://exploreCourses.stanford.edu/CourseSearch/search?view=catalog&filter-coursestatus-Active=on&page=0&catalog=&q=stats&collapse=) or from authorized offerings in the Department of Statistics (http://explorecourses.stanford.edu/). The following courses are not offered this year but may be used by students who completed them in fulfillment of this requirement: CS 106A, MATH 180, MATH 171, MATH 115, MATH 113, MATH 104.

Courses below 200 level are generally not acceptable, with the following exceptions:

1. Statistics core courses (must complete all four courses):

   - STATS 116 Theory of Probability 3-5
   - STATS 191 Introduction to Applied Statistics 3-4
   - STATS 200 Introduction to Statistical Inference 3
   - STATS 217 Introduction to Stochastic Processes 3

   All must be taken for a letter grade. Students with prior background may replace each course with a more advanced course from the same area. Courses previously taken may be waived by the adviser, in which case they must be replaced by other graduate courses offered by the department.

2. Linear Algebra Mathematics requirement:

   - MATH 104 Applied Matrix Theory 3
   - MATH 113 Linear Algebra and Matrix Theory 3
   - MATH 115 Functions of a Real Variable 3
   - MATH 171 Fundamental Concepts of Analysis 3

   Substitution of other courses in Mathematics and Computer Science may be made with consent of the adviser (may be taken for a letter grade or credit/no credit).

3. Programming requirement:

   - CS 106A Programming Methodology 3-5
   - CS 106X Programming Abstractions (Accelerated) 3-5
   - CME 108 Introduction to Scientific Computing 3-4

   1 The following courses are not offered this year but may be used by students who completed them in fulfillment of this requirement: CS 137, CS 138.

4. At least four additional Statistics courses must be taken from graduate offerings in the department (202-399). All must be taken for a letter grade. Students cannot count more than 6 units of STATS 260A, STATS 260B, STATS 260C Workshop in Biostatistics, STATS 298 Industrial Research for Statisticians, STATS 390 Consulting Workshop, STATS 299 Independent Study, and STATS 399 Research toward the master’s degree requirements.

5. Additional elective units to complete the requirements may be chosen from the list available from the department web site (http://www-stat.stanford.edu/academics/msc_electives.html). Other graduate courses (200 or above) may be authorized by the adviser if they provide skills relevant to statistics or deal primarily with an application of statistics or probability and do not overlap courses in the student’s program. There is sufficient flexibility to accommodate students with interests in applications to business, computing, economics, engineering, health, operations research, and biological and social sciences.

Courses below 200 level are generally not acceptable, with the following exceptions:

---

Data Analysis and Applied Statistics (6)

- STATS 202 Data Mining and Analysis 3
- STATS 203 Introduction to Regression Models and Analysis of Variance 3

Statistical Methodology (9)

- STATS 205 Introduction to Nonparametric Statistics 3
- STATS 206 Applied Multivariate Analysis 3
- STATS 207 Introduction to Time Series Analysis 3

Economic Optimization (8)

- STATS 206 Applied Multivariate Analysis 3
- ECON 160 Game Theory and Economic Applications 5

Psychology Modeling and Experiments (3)

- STATS 206 Applied Multivariate Analysis 3

Signal Processing (9)

- STATS 207 Introduction to Time Series Analysis 3
- EE 264 Digital Signal Processing 3
- EE 279 Introduction to Digital Communication 3

Genetic and Ecologic Modeling (6)

- STATS 217 Introduction to Stochastic Processes 3
- BIO 283 Theoretical Population Genetics 3

Probability and Applications (6)

- STATS 217 Introduction to Stochastic Processes 3
- STATS 218 Introduction to Stochastic Processes 3

Mathematical Finances (9-11)

- STATS 240 Statistical Methods in Finance 3-4
- STATS 243 Statistical Models and Methods for Risk Management and Surveillance 3-4
- STATS 250 Mathematical Finance 3

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Select one of the following:

- MATH 104 Applied Matrix Theory 3
- MATH 113 Linear Algebra and Matrix Theory 3
- MATH 115 Functions of a Real Variable 3
- MATH 171 Fundamental Concepts of Analysis 3

Substitution of other courses in Mathematics and Computer Science may be made with consent of the adviser (may be taken for a letter grade or credit/no credit).

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Select one of the following:

- CS 106A Programming Methodology 3-5
- CS 106X Programming Abstractions (Accelerated) 3-5
- CME 108 Introduction to Scientific Computing 3-4

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Units

- STATS 202 Data Mining and Analysis 3
- STATS 203 Introduction to Regression Models and Analysis of Variance 3
- STATS 205 Introduction to Nonparametric Statistics 3
- STATS 206 Applied Multivariate Analysis 3
- STATS 207 Introduction to Time Series Analysis 3
- STATS 206 Applied Multivariate Analysis 3
- ECON 160 Game Theory and Economic Applications 5
- STATS 206 Applied Multivariate Analysis 3
- EE 264 Digital Signal Processing 3
- EE 279 Introduction to Digital Communication 3
- STATS 217 Introduction to Stochastic Processes 3
- BIO 283 Theoretical Population Genetics 3
- STATS 217 Introduction to Stochastic Processes 3
- STATS 218 Introduction to Stochastic Processes 3
- STATS 240 Statistical Methods in Finance 3-4
- STATS 243 Statistical Models and Methods for Risk Management and Surveillance 3-4
- STATS 250 Mathematical Finance 3

- MATH 104 Applied Matrix Theory 3
- MATH 113 Linear Algebra and Matrix Theory 3
- MATH 115 Functions of a Real Variable 3
- MATH 171 Fundamental Concepts of Analysis 3
- CS 106A Programming Methodology 3-5
- CS 106B Programming Abstractions 3-5

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Units

- STATS 116 Theory of Probability 3-5
- STATS 191 Introduction to Applied Statistics 3-4
- STATS 200 Introduction to Statistical Inference 3
- STATS 217 Introduction to Stochastic Processes 3

- MATH 104 Applied Matrix Theory 3
- MATH 113 Linear Algebra and Matrix Theory 3
- MATH 115 Functions of a Real Variable 3
- MATH 171 Fundamental Concepts of Analysis 3
- MATH 180 Introduction to Financial Mathematics 3
- CS 106A Programming Methodology 3-5
- CS 106B Programming Abstractions 3-5

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Units

- STATS 116 Theory of Probability 3-5
- STATS 191 Introduction to Applied Statistics 3-4
- MATH 104 Applied Matrix Theory 3
- MATH 113 Linear Algebra and Matrix Theory 3
- MATH 115 Functions of a Real Variable 3
- MATH 171 Fundamental Concepts of Analysis 3
- MATH 180 Introduction to Financial Mathematics 3
- CS 106A Programming Methodology 3-5
- CS 106B Programming Abstractions 3-5
Educational activities towards computational biology, mathematical finance for admission. In particular, the department is expanding its research and students with degrees in other scientific fields are also encouraged to apply for the doctoral program. Quantitatively oriented undergraduate or master’s level work in mathematics and statistics provides a good background for the doctoral program. Advanced students with degrees in other scientific fields are also encouraged to apply for admission. In particular, the department is expanding its research and educational activities towards computational biology, mathematical finance and information science, via a VIGRE program. The program normally takes four years to complete.

Program Summary

First-year core program (18-34)

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 300A</td>
<td>Theory of Statistics</td>
<td>2-3</td>
</tr>
<tr>
<td>STATS 300B</td>
<td>Theory of Statistics</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 300C</td>
<td>Theory of Statistics</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 305</td>
<td>Introduction to Statistical Modeling</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 306A</td>
<td>Methods for Applied Statistics</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 300B</td>
<td>Theory of Statistics</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 310A</td>
<td>Theory of Probability</td>
<td>2-4</td>
</tr>
<tr>
<td>STATS 310B</td>
<td>Theory of Probability</td>
<td>2-3</td>
</tr>
<tr>
<td>STATS 310C</td>
<td>Theory of Probability</td>
<td>2-4</td>
</tr>
</tbody>
</table>

• Pass two of three parts of the qualifying examinations (end of first year); breadth requirement (second or third year); successfully complete the thesis proposal meeting (before end of third year); pass the University oral examination (fourth year); dissertation (fourth year).

• In addition, students are required to take 9 units of advanced topics courses offered by the department:

At most, one of these courses may be counted:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 104</td>
<td>Applied Matrix Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH 113</td>
<td>Linear Algebra and Matrix Theory</td>
<td>3</td>
</tr>
<tr>
<td>MATH 151</td>
<td>Introduction to Probability Theory</td>
<td>3</td>
</tr>
<tr>
<td>STATS 116</td>
<td>Theory of Probability</td>
<td>3-5</td>
</tr>
</tbody>
</table>

6. Submission of approved Masters Program Proposal (http://exploredegrees.stanford.edu/schoolofhumanitiesandsciences/statistics/STATS_MS_Program_Proposal_Form_2011.pdf) by the master’s adviser to the student services officer by the end of the first quarter of the master’s degree program.

Students with a strong mathematical background who may wish to go on to a Ph.D. in Statistics should consider applying to the Ph.D. program.

The eight Statistics courses required for the M.S. degree must be taken for letter grades. Courses other than the eight required statistics courses may be taken for a letter grade or Credit/No Credit. There is no thesis requirement. An overall 2.75 grade point average (GPA) is required.

Units for a given course may not be counted to meet the requirements of more than one degree, that is, no units may be double-counted.

Students pursuing a coterminal master’s degree must complete their requirements within three years of their first quarter of graduate standing. No courses taken more than two quarters prior to admission to the coterminal master’s program may be used to meet the 45-university minimum requirement for the master’s degree.

For further information about the Statistics master’s degree program requirements, see the department web site (http://www-stat.stanford.edu/academics/msc.html).

Doctor of Philosophy in Statistics

The department looks for students who wish to prepare for research careers in statistics or probability, either applied or theoretical. Advanced undergraduate or master’s level work in mathematics and statistics provides a good background for the doctoral program. Quantitatively oriented students with degrees in other scientific fields are also encouraged to apply for admission. In particular, the department is expanding its research and educational activities towards computational biology, mathematical finance and information science, via a VIGRE program. The program normally takes four years to complete.

Qualifying Examinations

These are intended to test the student’s level of knowledge when the first-year program, common to all students, has been completed. There are separate examinations in the three core subjects of statistical theory and methods, applied statistics, and probability theory, and all are typically taken during the summer between the student’s first and second years. Students may take two or three of these examinations and are expected
to show acceptable performance in two examinations. Letter grades are not given. After passing the qualifying exams, students will file for Ph.D. candidacy, a University milestone.

### Breadth Requirement

Students are advised to choose an area of concentration in a specific scientific field of statistical applications; this can be realized by taking at least 15 units of course work approved by the Ph.D. program adviser. Current areas with suggested course options include:

**Computational Biology and Statistical Genomics**

Students are expected to take 9 units of graduate courses in genetics or neurosciences (imaging), such as GENE 203/BIO 203 (Advanced Genetics), as well as 9 units of classes in Statistical Genetics or Bioinformatics:

Courses can be chosen from the following list:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 345</td>
<td>Computational Algorithms for Statistical Genetics</td>
<td>2-3</td>
</tr>
<tr>
<td>STATS 366</td>
<td>Modern Statistics for Modern Biology</td>
<td>3</td>
</tr>
</tbody>
</table>

1 The following courses are not offered this year but may be used by students who completed them in fulfillment of this requirement: GENE 344A, GENE 344B, STATS 367.

**Machine Learning**

Courses can be chosen from the following list:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 317</td>
<td>Statistical Learning (4-6)</td>
<td></td>
</tr>
<tr>
<td>STATS 315A</td>
<td>Modern Applied Statistics: Learning</td>
<td>2-3</td>
</tr>
<tr>
<td>STATS 315B</td>
<td>Modern Applied Statistics: Data Mining</td>
<td>2-3</td>
</tr>
<tr>
<td>CS 245</td>
<td>Database Systems Principles</td>
<td>3</td>
</tr>
<tr>
<td>CS 347</td>
<td>Parallel and Distributed Data Management</td>
<td>3</td>
</tr>
<tr>
<td>CS 221</td>
<td>Artificial Intelligence: Principles and Techniques</td>
<td>3-4</td>
</tr>
<tr>
<td>CS 354</td>
<td>Topics in Circuit Complexity</td>
<td>3</td>
</tr>
<tr>
<td>CS 229</td>
<td>Machine Learning</td>
<td>3-4</td>
</tr>
</tbody>
</table>

1 CS 346 is not offered this year, but the department may offer it next year. If so, this course may be used in fulfillment of this requirement.

**Applied Probability**

Students are expected to take 15 units of graduate courses in some of the following areas:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 317</td>
<td>Statistical Learning (4-6)</td>
<td></td>
</tr>
<tr>
<td>MS&amp;E 322</td>
<td>Stochastic Calculus and Control</td>
<td>3</td>
</tr>
<tr>
<td>MS&amp;E 351</td>
<td>Dynamic Programming and Stochastic Control</td>
<td>3</td>
</tr>
<tr>
<td>STATS 250</td>
<td>Mathematical Finance</td>
<td>3</td>
</tr>
<tr>
<td>FINANCE 622</td>
<td>Dynamic Asset Pricing Theory</td>
<td>4</td>
</tr>
<tr>
<td>MATH 236</td>
<td>Introduction to Stochastic Differential Equations</td>
<td>3</td>
</tr>
</tbody>
</table>

**Earth Science Statistics**

Students are expected to take:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 317</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>STATS 318</td>
<td>Modern Markov Chains</td>
<td>3</td>
</tr>
<tr>
<td>STATS 352</td>
<td>Spatial Statistics</td>
<td>3</td>
</tr>
</tbody>
</table>

Three courses from the GES or Geophysics departments, such as GES 144.

1 GES 144 is no longer offered but may be used by students who completed the course in fulfillment of this requirement.

**Social and Behavioral Sciences**

Students are expected to take three advanced courses from the department with an applied orientation such as:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATS 261/262</td>
<td>Intermediate Biostatistics: Analysis of Discrete Data</td>
<td>3</td>
</tr>
<tr>
<td>STATS 324</td>
<td>Multivariate Analysis</td>
<td>2-3</td>
</tr>
</tbody>
</table>

1 The following courses are not offered this year but may be used by students who completed them in fulfillment of this requirement: STATS 343, 354.

In addition, students must complete at least three advanced quantitative courses from departments such as Anthropology, Economics, Political Science, Psychology, and Sociology, and the schools of Education, Business, or Medicine.

**Thesis Proposal Meeting and University Oral Examinations**

The thesis proposal meeting is intended to demonstrate students’ depth in some areas of statistics, and to examine the general plan for their research. It also confirms that students have chosen a Ph.D. faculty adviser and have started to work with that adviser on a research topic. In the meeting, they will give a short presentation and discuss their ideas for completing a PhD thesis, with a committee consisting of their adviser and thesis committee (a total of four members). The meeting must be successfully completed before the end of their third year. “Successful completion” means that the general research plan is sound and has a reasonable chance of success. If they do not successfully complete the meeting to the satisfaction of the committee, then the meeting must be repeated. Repeated failure can lead to a loss of financial support.

The oral examination consists of a 40-minute presentation on the thesis topic, followed by a question period. The questions relate both to the student’s presentation and also explore the student’s familiarity with broader statistical topics related to the thesis research. The oral examination is normally completed within the last few months of the student’s Ph.D. period. The examining committee usually consists of four faculty members from the Statistics Department and a fifth faculty member from outside the department. Four out of five passing votes are required and no grades are
Nearly all students can expect to pass this examination, although it is common for specific recommendations to be made regarding completion of the thesis.

A reading committee must also read and approve the thesis. The reading committee is typically the same as the thesis committee from the thesis proposal meeting.

For further information on University oral examinations and committees, see the Graduate Academic Policies and Procedures (GAP) Handbook, section 4.7 (http://gap.stanford.edu/4-7.html) or the "University Oral Examination (http://exploredegrees.stanford.edu/archive/2012-13/graduatedegrees/#doctoralthesis)" section of this bulletin.

**Doctoral and Research Advisers**

From the student’s arrival until the selection of a research adviser, the student’s academic progress is monitored by the department Doctoral Adviser. Each student should meet at least once a quarter with the Doctoral Adviser to discuss their academic plans and their progress towards choosing a thesis adviser.

**Financial Support**

Students accepted to the Ph.D. program are offered financial support. All tuition expenses are paid and there is a fixed monthly stipend determined to be sufficient to pay living expenses. Financial support can be continued for five years, department resources permitting, for students in good standing. The resources for student financial support derive from funds made available for student teaching and research assistantships. Students receive both a teaching and research assignment each quarter which, together, do not exceed 20 hours. Students are encouraged to apply for outside scholarships, fellowships, and other forms of financial support.

**Ph.D. Minor in Statistics**

Students must complete 30 total units for the Ph.D. minor. 20 units must be from Statistics courses numbered 300 and above and taken for letter grades. The remaining 10 units can be from Statistics courses numbered 200 and above. The selection of courses must be approved by one of the M.S. advisers. The Application for the Ph.D. Minor form must be approved by both the student’s Ph.D. department and the Statistics department.

For further information about the Statistics Ph.D. degree program requirements, see the department web site (http://www-stat.stanford.edu/academics/msc.html).

_Emeriti:_ Theodore W. Anderson, Jerome H. Friedman, Ingram Olkin, Charles Stein, Paul Switzer

_Chair:_ Guenther Walther


_Associate Professors:_ Andrea Montanari, Jonathan Taylor

_Assistant Professors:_ Balakanapathy Rajaratnam

_Courtesy Professors:_ John Ioannidis, Philip W. Lavori, Richard A. Olshen, Hua Tang

_Courtesy Associate Professors:_ Simon Jackman, David Rogosa, Chiara Sabatti

_Consulting Professors:_ John Chambers, Charles Chui

_Stein Fellows:_ Michael Baiocchi, Sergio Bacallado