
Statistics

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Statistics is a relatively young discipline organized around the rapidly growing body of knowledge about quantitative methods for the analysis of data, the making of rational decisions under uncertainty, the design of experiments, and the modeling of randomness in the social and natural sciences. Statistics has a theoretical core surrounded by a large number of domains of application in fields such as economics, psychology, biology and medicine, sociology, population sciences, government, anthropology, history, astronomy, physics, and computer science. A basic requirement of a concentration in Statistics is to acquire the mathematical tools for a rigorous understanding of applications to substantive fields. This includes linear algebra and multivariate calculus to the level of Mathematics or Applied Mathematics 21b.

A non-mathematical introduction to the field is provided by Statistics 100: Introduction to Quantitative Methods. The basic theoretical introduction is provided by Statistics 110: Introduction to Probability, and Statistics 111: Introduction to Theoretical Statistics. These courses provide grounding in traditional and modern approaches to modeling, exploratory inference, and testing and estimation. They should equip students to take the other Department of Statistics courses dealing in greater detail with special models and procedures, as well as to move into applied fields.

The Statistics concentration is a flexible program that permits as many as half of the 14 half-courses required for honors eligibility to be taken in departments other than Statistics. Because Statistics offers an opportunity to branch out and explore a variety of areas it appeals to students who wish to acquire core skills while preserving their chance for a broad general education. It also appeals to those with strong mathematical interests who enjoy seeing formal argument bear direct fruit in practical use.

A concentration in Statistics prepares a student for careers in industry and government, for graduate study in a very broad collection of social and natural sciences, and for professional study in law, medicine, business, or public administration. The demand for people with statistical training is rising in most areas.

Students may choose to transfer to Statistics after a taste of other fields. Such transfers usually pose no difficulty. Statistics may be combined with other concentrations in an honors-eligible program. Joint concentrations with many fields are possible, including Economics, Psychology, Computer Science, and Social Studies.

In 2006-07 the Department of Statistics introduced the Bioinformatics and Computational Biology Track in Statistics, aimed at undergraduate students with interest in quantitative methods and modeling applied to data from the biological and life sciences. The recent explosion of size and complexity of data in the biological and life sciences, such as the human/animal/plants genome projects with gene and protein sequences, has motivated the development of new statistical methodologies and models, such as models for gene and protein motifs search, phylogenetic reconstruction, and gene expression analysis. Core requirements in statistics emphasize statistical modeling, especially as it relates to biological systems. Additional courses in biology allow students to learn the terminology as well to obtain a strong foundation in molecular and cellular biology, evolutionary biology, or ecology. The requirements for the Bioinformatics and Computational Biology Track are described in detail below.

In 2007-08 the Department of Statistics introduces the Quantitative Finance Track, which is designed as a specialization for concentrators in Statistics with special interest in quantitative issues that arise in financial and insurance modeling. The focus is on the stochastic analysis that

is relevant in these fields. The specific topics addressed include statistical inference of stochastic models that arise in financial/insurance modeling as well as computational techniques that have become standard in pricing, hedging and risk assessment of complex financial/insurance instruments. The requirements for the Quantitative Finance Track are described in detail below.

In 2007-08, the Department of Statistics also introduces the secondary field in Statistics. With its strong methodological and applications focus, Statistics has consequently attracted students with a primary focus in another discipline, such as Psychology, Economics, Sociology, Government, Earth and Planetary Sciences, Biology (both OEB and MCB). The secondary field in Statistics will provide these students with a solid background in statistics that they can apply in their primary field or fields of interest. For more information on the secondary field in Statistics, please see page 381 of this *Handbook* or the secondary fields website (www.secondaryfields.fas.harvard.edu/stats/program-desc-stats.htm).

REQUIREMENTS

Basic Requirements: 12 half-courses

1. *Required courses:*
 - a. Seven half-courses from Statistics Department offerings (100 or 101 or 102 or 104, 105, 110, 111, 120, 131, 135, 139, 140, 155, 149, 160, 170, 171, and any 200-level course); Statistics 110 and 111 are required and should be taken by the end of the junior year. Statistics 91r and 99hf may count toward this requirement.
 - b. Five additional half-courses, which may be related courses (see item 5a).
 - c. Mathematics 19a and 19b, Mathematics 21a and 21b, Applied Mathematics 21a and 21b, or equivalents, are required by the end of the sophomore year and may count for two related half-courses toward concentration requirements.
2. *Tutorial:* Senior year: Statistics 99hf optional. Letter-graded.
3. *Thesis:* None.
4. *General Examination:* None.
5. *Other information:*
 - a. Related courses:
 - i. Applied Mathematics 21a, 21b, 101 (formerly Engineering Sciences 101), 105a, 105b, 106, 107, 111, 115, 120, 121 (formerly Engineering Sciences 102)
 - ii. Astronomy 193
 - iii. Biophysics 101
 - iv. Computer Science 50, 51
 - v. Economics 1123, 1126, 2110, 2120, 2130, 2140, 2141, 2142, 2144, 2146
 - vi. Engineering Sciences 101, 102, 201, 202, 203
 - vii. Government 1007, 1010, 2000, 2001, 2002, 2003
 - viii. Mathematics 19a, 19b, 21a, 21b, 23a, 23b, 25a, 25b, 106, 112, 113, 115, 116, 121, 122, 123
 - ix. MCB 111 (formerly MCB 211)
 - x. OEB 152
 - xi. Physics 181, 262
 - xii. Psychology 1950, 1951, 1952
 - xiii. Quantitative Reasoning 32, 33
 - xvi. Any 100-level or 200-level Statistics courses
 - xv. Other relevant courses if approved by the Head Tutor.
 - b. *Pass/Fail:* One half-course other than Statistics 110 and 111 may be taken Pass/Fail and counted for concentration credit.

- c. All courses taken for concentration credit must be approved by the Head Tutor.
- d. *Undergraduate Teacher Education Program*: Concentrators may be eligible to obtain certification to teach in middle or secondary schools in Massachusetts and the forty-one states with which Massachusetts has reciprocity. See page 47 for more information about UTEP.

REQUIREMENTS FOR HONORS ELIGIBILITY

14 half-courses plus thesis

1. *Required courses*: Same as **Basic Requirements** with two additional half-courses, which may be related (see item 5a).
2. *Tutorial*: Same as **Basic Requirements**.
3. *Thesis*: Required. A substantial statistical analysis of a real-life problem, a critical review of statistical methods in some problem areas, or the solution of an open statistical research problem are equally acceptable. Students may enroll in Statistics 99hf while writing the thesis, but it is not required.
4. *General Examination*: None.
5. *Other information*: Same as **Basic Requirements**.
6. *Joint Concentrations*: Students interested in a joint concentration should consult the Head Tutor at an early date.
 - a. *Statistics as the Primary Field*: Students must satisfy the usual requirements for honors eligibility. In addition, students must complete four half-courses in the allied field (some of these may count as statistics-related courses). Note that some fields may require more than four half-courses. Thesis required; must relate to both fields. Ordinarily there will be two readers, one from each field.
 - b. *Another concentration as the Primary Field*: Students are required to complete five half-courses from Statistics Department offerings (Statistics 110 and 111 are required by the end of the junior year). One additional half-course, which may be a statistics-related course from the primary field, is also required. Students may receive credit for only one course at the level of Statistics 100 (others at the same level include Statistics 101, 102, 104; Government 1000; OEB 153). Mathematics preparation to the level of Mathematics or Applied Mathematics 21b is required. Thesis required; must relate to both fields. There must be a reader from the Statistics Department.

Bioinformatics and Computational Biology (BCB) Track in Statistics

Basic Requirements: 12 half-courses

1. *Required courses*:
 - a. Same as **Basic Requirements**, but must also include Statistics 102, 115, and 171 and Life Sciences 1a and 1b. Life Sciences 1a and 1b may count for two related half-courses toward concentration requirements.
 - b. Five additional half-courses, which may be related courses (see item 5a below).
 - c. Mathematics 19a and 19b, Mathematics 21a and 21b, Applied Mathematics 21a and 21b, or equivalents, are required by the end of the sophomore year and may count for two related half-courses toward concentration requirements.
2. *Tutorial*: Same as **Basic Requirements**.
3. *Thesis*: None.
4. *General Examination*: None.

5. *Other information:*
- a. Related Courses for the BCB Track: It is recommended that the student focus on one of the following categories, and choose at least one course above the 100 level.
 - i. *Molecular and Cellular Biology*: MCB 52, 54, 56, and select one from MCB 100, 111, 118, 140, 150
 - ii. *Evolutionary Biology and Ecology*: OEB 53, 55, and select one from OEB 125, 152, 181
 - iii. *Mathematical, Physical, and Statistical Biology*: Biophysics 101, 170; Mathematics 153; Biostatistics 244, 245, 280
 - iv. *Computer Science and Statistics*: Computer Science 50, 51; Statistics 131, 135, 139, 140, 149, 160
 Other relevant courses if approved by the Head Tutor.
 - b. *Pass/Fail*: One half-course other than Statistics 110 and 111 may be taken Pass/Fail and counted for concentration credit.
 - c. All courses taken for concentration credit must be approved by the Head Tutor.
 - d. *Undergraduate Teacher Education Program*: Concentrators may be eligible to obtain certification to teach in middle or secondary schools in Massachusetts and the forty-one states with which Massachusetts has reciprocity. See page 47 for more information about UTEP.

The Bioinformatics and Computational Biology (BCB) Track in Statistics Requirements for Honors Eligibility: 14 half-courses plus thesis

1. *Required courses*: Same as **Basic Requirements** with two additional half-courses, which may be related courses (see item 5a above for the BCB Track).
2. *Tutorial*: Same as **Basic Requirements**.
3. *Thesis*: Required. A substantial statistical analysis of a biological studies problem, a critical review of statistical methods in some biological areas, or the solution of an open statistical research problem in a biology-related area are equally acceptable. Students may enroll in Statistics 99hf while writing the thesis, but it is not required.
4. *General Examination*: None.
5. *Other information*: Same as **Basic Requirements**.

Quantitative Finance Track in Statistics Basic Requirements: 12 half-courses

1. *Required courses*:
 - a. *Six Statistics courses*:
 - i. Statistics 110 (Prerequisite: Mathematics 19a or equivalent)
 - ii. Statistics 111 (Prerequisites: Statistics 110 and Math 19b or equivalent)
 - iii. Statistics 131, 139, 170, 171. Statistics 139 can be replaced by either Economics 1123 or 1126.
 - b. *Three Economics courses*:
 - i. Economics 1010a or 1011a (strongly recommended by department). Social Analysis 10 is prerequisite for both.
 - ii. Economics 1723 (prerequisite: Economics 1010a or 1011a)
 - iii. One of the following: Economics 1733, 1745, 1760.
 - c. *Three related courses for the Quantitative Finance Track*:
 - i. Statistics 135, 149, 214, 220, 221, 230, 249, 270, 271

- ii. Economics 1123, 1126, 2120, 2140, 2142, 2723, 2724, 2725, 2728
- iii. Computer Science 50, 51
- iv. MIT Finance 15.401, 15.402, 15.433, 15.437

Note: Graduate-level courses may not be suitable for all undergraduates because they often have higher prerequisites. Students who are interested in taking them must check with the instructors to gain permission prior to enrollment.

- 2. *Tutorial:* Same as **Basic Requirements**.
- 3. *Thesis:* None.
- 4. *General Examination:* None.
- 5. *Other Information:* Mathematics 19a and 19b, Mathematics 21a and 21b, Applied Mathematics 21a and 21b, or equivalents, are required but do not count for concentration credit. This requirement should be completed by the end of the sophomore year.

Quantitative Finance Track in Statistics Requirements for Honors Eligibility: 14 half-courses plus thesis

- 1. *Required courses:* Same as **Basic Requirements** with two additional half-courses, which may be related courses (see item 1c above for the Quantitative Finance Track).
- 2. *Tutorial:* Same as **Basic Requirements**.
- 3. *Thesis:* Required. A substantial statistical analysis of a quantitative finance problem, a critical review of statistical methods in some finance area, or the solution of an open statistical research problem in a finance-related area are equally acceptable. Students may enroll in Statistics 99hf while writing the thesis, but it is not required.
- 4. *General Examination:* None.
- 5. *Other Information:* Same as **Basic Requirements**.

ADVISING

The Co-Head Tutors are advisers to all Statistics concentrators. It is expected that students will discuss their program and review their progress with the Co-Head Tutors at the beginning of each term.

For up-to-date information on advising in Statistics, please see the Advising Programs Office website: www.fas.harvard.edu/~advising/concentrations/Statistics.html.

HOW TO FIND OUT MORE

For more information please consult with the Co-Head Tutors, Professor Rima Izem, Science Center 604 (617-496-8456, izem@stat.harvard.edu) and Professor David Harrington, Science Center 607 (david_harrington@harvard.edu).

ENROLLMENT STATISTICS

Number of Concentrators as of November

Concentrators	2002	2003	2004	2005	2006
Statistics	9	8	8	4	7
Statistics + another field	0	1	1	1	1
Another field + Statistics	2	2	2	3	4