

Economics and Statistics, B.S.

B.S. in Economics and Statistics

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The Bachelor of Science in Economics and Statistics trains students in statistical theory, methods, applications, and judgment, such that they can make real-world impacts. Furthermore, students gain in-depth economics training, so that students can analyze data to inform economic policy, make business decisions, and/or make financial forecasts. This degree is especially relevant for students interested in financial and business-relevant applications, as well as students who want to pursue graduate programs in economics, finance, and related fields.

Curriculum

The requirements for the B.S. in Economics and Statistics are the following:

1. Mathematical Foundations (prerequisites) 39-52 units

Mathematics is the language in which statistical models are described and analyzed, so some experience with basic calculus and linear algebra is an important component for anyone pursuing a program of study in Economics and Statistics.

Complete the following:

21-090	Precalculus	10
Complete one of the following options:		
21-111	Differential Calculus	10
21-112	Integral Calculus	10
OR		
21-120	Differential and Integral Calculus	10
And one of the following four courses:		
21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	10
21-266	Vector Calculus using Matrix Algebra	10
21-268	Multidimensional Calculus	11
And one of the following three courses:		
21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	11
21-242	Matrix Theory	11

Notes:

- Passing the Mathematical Sciences assessment tests available during First-Year Orientation is an acceptable alternative to completing 21-090 and/or 21-120.
- It is recommended that students complete the calculus requirement during their freshman year.
- 21-266 and 21-268 are intended for students with a very strong mathematical background.
- The linear algebra requirement needs to be completed before taking 36-401 Modern Regression.
- 21-241 and 21-242 are intended only for students with a very strong mathematical background.

2. Economics Foundations 18 units

Take one of the following courses:

73-102	Principles of Microeconomics *	9
73-104	Principles of Microeconomics Accelerated **	9

Take the following course:

73-103	Principles of Macroeconomics	9
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- * Students who place out of 73-102 Principles of Microeconomics based on the economics placement exam will receive a pre-req waiver for 73-102 and are waived from taking 73-102.
- ** This course requires students to complete a 4 or 5 on the AP Microeconomics exam or qualifying score on the IB/Cambridge Exams. 73-104 will substitute for any 73-102 prerequisite requirement in other courses. 73-104 is a more rigorous introduction to microeconomics, is taught at a faster pace than 73-102, and dives a bit deeper into key topics. It is designed for students who have prior knowledge to fundamental economic concepts through AP/IB/Cambridge coursework. Enrollment in 73-104 requires special permission. Students who wish to take this course should add themselves to the 73-104 waitlist once registration opens. The Tepper School will verify the advancement placement scores and will enroll students in 73-104.

3. Statistical Foundations 27 units

Data Analysis

Data analysis is the art and science of extracting insight from data. The art lies in knowing which displays or techniques will reveal the most interesting features of a complicated data set. The science lies in understanding the various techniques and the assumptions on which they rely. Both aspects require practice to master.

The Beginning Data Analysis courses give a hands-on introduction to the art and science of data analysis. The courses cover similar topics but differ slightly in the examples they emphasize. 36-200 draws examples from many fields and satisfy the Dietrich College Core Requirement in Statistical Reasoning. This course is therefore required for students in the college. (Note: a score of 5 on the Advanced Placement [AP] Exam in Statistics may be used to waive this requirement). 36-220 emphasizes examples in engineering.

The Advanced Data Analysis courses draw on students' previous experience with data analysis and understanding of statistical theory to develop advanced, more sophisticated methods. These core courses involve extensive analysis of real data with emphasis on developing the oral and writing skills needed for communicating results.

Beginning Data Analysis

Choose *one* of the following courses:

36-200	Reasoning with Data *	9
36-220	Engineering Statistics and Quality Control	9

- * A score of 5 on the Advanced Placement (AP) Exam in Statistics may be used to waive this requirement. 36-220 emphasizes examples in engineering and Architecture.

Note: Students who enter the program with credit for probability and statistical inference should discuss options with an advisor.

Advanced Statistics Elective

Choose *two* of the following courses:

36-311	Statistical Analysis of Networks	9
36-313	Statistics of Inequality and Discrimination	9
36-318	Introduction to Causal Inference	9
36-319	Statistics and Machine Learning for the Physical Sciences	9
36-460	Special Topics: Sports Analytics	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Statistical Machine Learning	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Psychometrics: A Statistical Modeling Approach	9
36-465	Special Topics: Conceptual Foundations of Statistical Learning	9
36-466	Special Topics: Statistical Methods in Finance	9

36-467	Special Topics: Data over Space & Time	9
36-468	Special Topics: Text Analysis	9
36-469	Special Topics: Statistical Genomics and High Dimensional Inference	9
36-470	Special Topics: Statistical Methods in Health Sciences	9
36-471	Special Topics: Time Series	9
36-472	Special Topics: Computational Statistical Methods in Life Sciences	9
36-473	Special Topics: Statistical Principles of Generative AI	9
36-490	Undergraduate Research	9
36-493	Sports Analytics Capstone	9
36-497	Corporate Capstone Project	9

Note: All Special Topics are not offered every semester, and new Special Topics are regularly added.

4. Economics Core 27 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
70-340	Business Communications	9

5. Economics Quantitative Analysis Requirements 27 units

Complete the following:

73-265	Economics and Data Science	9
73-274	Econometrics I	9

Take one of the following courses:

73-374	Econometrics II	9
73-423	Forecasting for Economics and Business	9
70-467	Machine Learning for Business Analytics	9

6. Probability Theory and Statistical Theory 18 units

The theory of probability gives a mathematical description of the randomness inherent in our observations. It is the language in which statistical models are stated, so an understanding of probability is essential for the study of statistical theory. Statistical theory provides a mathematical framework for making inferences about unknown quantities from data. The theory reduces statistical problems to their essential ingredients to help devise and evaluate inferential procedures. It provides a powerful and wide-ranging set of tools for dealing with uncertainty.

To satisfy the theory requirement, complete the following:

36-235	Probability and Statistical Inference I *	9
36-236	Probability and Statistical Inference II **	9

* It is possible to substitute 36-218, 36-219, 36-225, 15-259, or 21-325 for 36-235. 36-235 is the standard introduction to probability, 36-219 is tailored for engineers and computer scientists, 36-218 and 15-259 are more mathematically rigorous classes for Computer Science students and more mathematically advanced Statistics students (Statistics students need advisor approval to enroll), and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.

** It is possible to substitute 36-226 or 36-326 for 36-236. 36-236 is the standard introduction to statistical inference.

Notes:

- In order meet the prerequisite requirements for the major, a grade of C or better is required in 36-235 (or equivalents), 36-236 or 36-326 and 36-401.
- Please note that students who complete 36-235 are expected to take 36-236 to fulfill their theory requirements. Students who choose to take 36-225 instead will be required to take 36-226 afterward, they will not be eligible to take 36-236.

7. Modern Regression and Advanced Methodology 18 units

Central to the practice of statistics is the implementation and interpretation of statistical models. The purpose of statistical models is to represent data-generating processes, such that predictions and inferential conclusions can be made about real-world phenomena. Proper modeling involves not

just coding, but also thinking critically about data, research goals, and the validity of the models themselves, given their intrinsic assumptions. The courses 36-401 and 36-402 focus on the theory of statistical models (especially linear models and their extensions), how they are applied in real data analyses, and how to interpret and present these analyses in written reports. **36-401 and 36-402 must be taken in residence at Carnegie Mellon University. Transfer credit will not be accepted.**

Complete the following courses:

36-401	Modern Regression *	9
36-402	Advanced Methods for Data Analysis	9

* In order to meet the prerequisite requirements, a grade of at least a C is required in 36-401.

8. Statistical Computing 19-21 units

Fundamental to the practice of statistics and data science is the ability to effectively code data processing and analysis tasks. Within the domain of statistics, the use of the programming language R is ubiquitous, and thus we expose students to it throughout the curriculum (and in depth in Statistical Computing). Within the larger domain of data science, the use of the programming language Python is also ubiquitous, and thus we require all majors to gain, at a minimum, basic competency in the language by taking either Principles of Computing, or Fundamentals of Programming and Computer Science. We would advise those students who are considering receiving course credit for one of these two courses given their score on the AP Computer Science A exam to actually take one (or both) of them at Carnegie Mellon instead, as within data science as a whole Python is far more widely used than Java.

Take one of the following two courses:

15-110	Principles of Computing	10
15-112	Fundamentals of Programming and Computer Science	12
02-120	Programming for Scientists	12

Complete the following course:

36-350	Statistical Computing	9
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9. Economics Electives 18 units

Students must take two advanced Economics elective courses, numbered 73-3xx and higher (excluding 73-497 and other colloquium and related courses).

73-374 Econometrics II or 73-423 Forecasting for Economics and Business can count toward the Advanced Economics Elective requirement if they are not being used to fulfill the Advanced Quantitative Analysis requirement.

Total number of units for the major 202-218 Units

Total number of units for the degree 360 Units

Additional Major in Economics and Statistics

Students who elect Economics and Statistics as an additional major must fulfill all Economics and Statistics degree requirements. Majors in many other programs would naturally complement an Economics and Statistics Major, including Tepper's undergraduate business program, Social and Decision Sciences, Policy and Management, and Psychology.

With respect to double-counting courses, it is departmental policy that students must have at least six courses [three Economics (73-xxx) and three Statistics and Data Science (36-xxx)] that do *not* count for their primary major. If students do not have at least three ECON and three STA classes, they will need to take additional advanced data analysis or economics electives, depending on where the double-counting issue is.

Students are advised to begin planning their curriculum (with appropriate advisors) as soon as possible. This is particularly true if the other major has a complex set of requirements and prerequisites or when many of the other major's requirements overlap with the requirements for a Major in Economics and Statistics.

Note on additional major and minor pairings: All students pursuing the B.S. in Economics and Statistics as a primary major are prohibited from also pursuing a minor or additional major in Economics due to the significant overlap in their respective curricula. Please see your academic advisor if you have further questions.

Sample Program

The following sample program illustrates one way to satisfy the requirements of the Economics and Statistics Major. Keep in mind that the program is flexible and can support other possible schedules (see footnotes below the schedule).

First-Year		Second-Year	
Fall	Spring	Fall	Spring
21-090 Precalculus	21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-236 Probability and Statistical Inference II
36-200 Reasoning with Data	73-103 Principles of Macroeconomics	36-235 Probability and Statistical Inference I	21-240 Matrix Algebra with Applications
73-102 Principles of Microeconomics	70-340 Business Communications	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
First-Year Writing	15-110 Principles of Computing	73-265 Economics and Data Science	73-274 Econometrics I
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Third-Year		Fourth-Year	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	36-3xx or 36-4xx Advanced Data Analysis Elective	36-3xx or 36-4xx Advanced Data Analysis Elective
36-401 Modern Regression	-----	Economics Elective	Economics Elective
Advanced Quantitative Analysis Course	-----	-----	-----
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In each semester, ----- represents other courses (not related to the major) which are needed in order to complete the 360 units that the degree requires.

Prospective PhD students are advised to add 21-127 fall of sophomore year, replace 21-240 with 21-241, add 21-260 in spring of junior year and 21-355 in fall of senior year.