

# Undergraduate Economics Program

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At its most fundamental level, economics is the study of how scarce resources are allocated. What will be produced and consumed, how much, and by whom? These questions are central to the well-being of people throughout the world. Economists identify, model, and analyze problems with the objective of developing practical and efficient solutions to challenges confronting society. Economists are also active participants in the processes and institutions through which economic policies are implemented. In the public arena sphere, economists contribute to design of programs and incentive systems to foster efficient implementation of policies. In the private sector, economists bring modeling and data-analytic skill to bear, both in identifying ways to enhance productive efficiency within the firm and in developing strategies to enhance effectiveness of the firm as it competes in the global marketplace. Increasingly, economists are taking advantage of advances in technology to design new exchange systems in applications as diverse as global electronic markets, kidney exchanges, pollution control, and school choice mechanisms.

Carnegie Mellon University enjoys a rich history of innovative research in the field of economics. The university has a distinctive culture that fosters collaborative, problem-oriented, theoretically rigorous, and empirically tested research. The success of this distinctive approach is manifest in the international recognition accorded past and present faculty, including nine Nobel Prizes in Economics. In the classroom, faculty bring the same rigorous, innovative approach to help develop the tremendous intellectual potential and analytic skills of students who are drawn to study economics at Carnegie Mellon. Project courses and hands-on applications in classes enable our students to gain valuable practical experience in honing their skills in economic reasoning, modeling, and data analysis.

The Undergraduate Economics Program has a unique position at Carnegie Mellon University. It is the sole undergraduate program that is a joint program of the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. The combination of research strength (Tepper has been home to nine Nobel Laureates in Economics) and commitment to liberal arts and interdisciplinary studies (Dietrich has "the most creative general education program of any American university" – New York Times) provides our undergraduates with a world-class economics program.

Economics majors are considered members of both colleges and enjoy the full support and services of both. Undergraduate economics students should consult the program's website for details about applicable Tepper and Dietrich academic policies and procedures.

## Educational Objectives

The Undergraduate Economics Program offers a range of degrees in economics designed to develop strong analytical skills and a solid foundation in the discipline of economics. More specifically, measurable objectives for our economics curriculum are the following:

- Students should be able to identify, explain, and use economic concepts, theories, models, and data-analytic techniques.
- Students should acquire and use knowledge of economics, mathematics, statistics, and computing flexibly in a variety of contexts, providing the foundation for success in graduate studies and careers in the public and private sectors.
- Students should be able to apply their economic tools to formulate positions on a wide range of social and economic problems and engage effectively in policy debates.
- Students should use the investigative skills necessary for conducting original economic research and participating effectively in project teams.
- Students should be able to deliver effective presentations in which they combine visual communication design with oral arguments and/or the written word.

## Academic Standards and Policies

Undergraduate economics students are in the unique position of belonging to two CMU colleges, Marianna Brown Dietrich College of Humanities and Social Sciences and the Tepper School of Business. To find a detailed description of the college and program policies governing economics students, please consult the undergraduate section of MyTepper (<http://mytepper.tepper.cmu.edu>).

## Advising

The Undergraduate Economics Program is committed to providing students with the opportunity to have meaningful and informative discussions about their academic, intellectual, and career interests with a wide range of advisors and mentors. Advising meetings are extended discussions which may address both immediate and long-term interests, concerns, and desires/needs. Students pursuing a degree in economics are assigned an economics advisor who meets with them on a regular basis. Any CMU undergraduate student interested in taking an economics course is invited to meet with an economics advisor. To facilitate scheduling advising meetings, please use the online appointment scheduler (<http://tepper.cmu.edu/undergradappt>).

The economics curriculum is cumulative; higher-level courses build upon the foundations learned in the core courses. This results in students needing to be aware of course-sequencing and the schedule of classes. Students are encouraged to meet frequently with their Undergraduate Economics Program academic advisor to ensure that their courses fulfill the requirements towards their degree and are appropriately sequenced. Successful students check-in with their advisor frequently and seek the advice of their academic advisor in selecting courses, pursuing additional degrees, and planning ahead for study abroad.

## First-Year Advising

First-year students who major in economics enter Carnegie Mellon University as Dietrich College students, and are assigned a Dietrich College Academic Advisory Center (<http://www.cmu.edu/hss/advisory-center>) (AAC) advisor. While the AAC advisors are the advisors of record until students formally declare their majors, students who are considering majoring in economics are encouraged to contact the Undergraduate Economics Program academic advisor so that they will have access to program resources; program-level advising; and the community of faculty, staff, and students.

First-year students are **not** expected to know which degree option they wish to pursue. For this reason, the first-year curricula are quite similar for the four primary degrees awarded by the program. As students become involved in their course work, participate in the extra- and co-curricular activities sponsored by the Undergraduate Economics Program, and have discussions with faculty and economics advisors, the decision of which degree to pursue becomes evident.

## Study Abroad

The Undergraduate Economics Program encourages students to consider enriching their undergraduate experience by studying abroad at some point during their undergraduate tenure. Studying abroad is widely defined as either study, work, internship, volunteer, or research opportunities abroad during your college career. Studying abroad provides students with not only more awareness of cultural literacies, but it further enhances their education by providing them with the opportunity to compare and contrast different economies and regimes. Many students consider their study abroad experience to be a watershed moment in their studies. With a bit of careful planning, study abroad can be worked into most any economics student's 4-year schedule.

## Preparation for Professional School Programs

Many economics students will attend professional graduate school programs (e.g., DDS, JD, MBA, MD, MPP, M.Sc. Finance, etc.) immediately after graduation or within the first five years of earning their undergraduate degree. Students who are considering applying to professional graduate schools are encouraged to meet with an economics advisor early in their career at CMU. The economics advisors can provide structure and information that are invaluable during a student's intellectual and career exploration. Knowing that the choice of courses, student achievement, extra- and co-curricular activities, professional school entrance exam test scores (e.g., GMAT, LSAT, MCAT, etc), and faculty recommendations are key determinants of acceptance into these varied programs, the economics advisors will help you plan your time at CMU.

## Preparation for Ph.D. Programs in Economics

The Undergraduate Economics Program has been successful in preparing students for admission into the nation's most competitive doctoral programs. The life of a researcher (whether in academia or in the private research sector) requires a set of skills that undergraduate students will begin to acquire through course work, research, and focused conversations with faculty and advisors. Doctoral programs in economics are looking for specific analytical skills. Key determinants of acceptance into these programs are the choice of courses, student achievement, research experience, graduate school entrance exam test scores (specifically the GRE), and faculty recommendations. Students who are considering pursuing a higher academic degree are encouraged to meet an economics advisor early in their career at CMU. Interested students are encouraged to look at the B.S. in Economics and Mathematical Sciences curriculum.

## Curricula

In order to accommodate students' wide variety of goals, four primary degree programs are available: Bachelor of Arts in Economics, Bachelor of Science in Economics, Bachelor of Science in Economics and Mathematical Sciences (jointly administered by the Department of Mathematics and the Undergraduate Economics Program), and Bachelor of Science in Economics and Statistics (jointly administered by the Department of Statistics and Data Science and the Undergraduate Economics Program).

The four major degree programs have been designed to provide students with a solid understanding of the central theories and analytical tools of the field of economics, while maintaining the flexibility necessary to meet the needs of a diversity of career paths. The four degrees produce strong analytical thinkers who are able to model and analyze complex problems. Graduates of the Undergraduate Economics Program gain employment as economic analysts in both the private and public sectors; pursue advanced professional degrees in business, law, and public policy; as well as enter into Ph.D. programs in economics, statistics, finance, and related fields.

For students who major in other academic fields, additional major programs in Economics and in Economics and Statistics and a minor degree program in Economics are available.

## Concentrations

The Undergraduate Economics Program offers six concentration areas which allow students to specialize in: Market Design, Economics of Global Change and Disruption, Strategy and Markets, Global Markets and Finance, Economics of Public Policy, and Advanced Quantitative Economics Methods. Concentrations consist of groups of mutually reinforcing economics electives that build off the economics core curriculum. These focused sets of electives allow a student to explore a group of allied topics, and/or develop a specialized and advanced skill set appropriate for a desired career. Students are not required to complete a concentration in order to earn a degree. See the program website (<http://mytepper.tepper.cmu.edu/current-students/undergraduate-students/economics/economics%20curriculum%20and%20courses>) for more details.

## Major Degree Requirements and Sample Schedules

In addition to completing a minimum 360 units and fulfilling both the Dietrich General Education requirements and all University requirements, recipients of an undergraduate degree in economics must complete courses in mathematics, probability and statistics, writing, economic theory, and economic analysis, as well as a set of advanced electives and other specialized courses. It is important for students to realize that degree requirements are actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Following the list of requirements for each degree are sample four-year course schedules for a student pursuing an undergraduate degree in economics. As there are many different ways of completing the requirements, students are strongly encouraged to meet with an economics advisor to tailor their courses to their own particular needs. Students are responsible for ensuring that they understand all of the program requirements and that they meet the necessary conditions for graduation. When planning course schedules, students must give consideration to all prerequisite and co-requisite requirements.

In addition to meeting university and college graduation requirements, the Undergraduate Economics Program has the additional requirement: Economics courses counting towards any economics primary degree, additional major, or minor must be completed with a grade of "C" or higher.

## B.A. in Economics

The B.A. in Economics provides a strong foundation in economic analysis and quantitative methods. The curriculum's breadth incorporates the study of political, historical, and social institutions so that students may use the economic toolkit to address the current challenges humanity faces. Built into the degree is the opportunity to study political, historical, cultural, and social institutions from other CMU departments; these courses are referred to as "Special Electives". The advanced data analysis component of the B.A. in Economics Curriculum pays additional attention to ordinal data and the study of surveys. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students pursuing this degree will be well-equipped to pursue graduate work (professional and academic), enter directly into the business world, or pursue public service.

All economics courses counting towards an economics degree must be completed with a grade of "C" or higher.

### B.A. in Economics Curriculum

**Total Number of Units for the Major: 166/175**

#### Mathematics Prerequisites (19 units)

Courses		Units
21-120	Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-256	Multivariate Analysis	9

#### Sophomore Economics Colloquium (3 units)

		Units
73-210	Economics Colloquium I	3

#### Writing Requirement (9 units)

		Units
73-270	Strategic Professional Communication for Economists	9

#### Economic Theory Requirements (36 units)

		Units
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

#### Quantitative Analysis Requirements (36 Units)

		Units
36-201	Statistical Reasoning and Practice	9
or 36-200	Reasoning with Data	
or 36-207	Probability and Statistics for Business Applications	
or 70-207	Probability and Statistics for Business Applications	
36-202	Methods for Statistics and Data Science	9
or 36-208	Regression Analysis	
or 70-208	Regression Analysis	
36-303	Sampling, Survey and Society	9
73-265	Economics and Data Science	9

#### Advanced Economics Electives (36 Units)

Students must take four advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II) as well as selected courses designated by the Program offered by other departments/programs.

Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability. Students have the option of earning a concentration (<http://mytepper.tepper.cmu.edu/current-students/undergraduate-students/economics/economics%20curriculum%20and%20courses>) by completing a set of interconnected electives. While a concentration area is not required for this degree, it is an additional option that allows students to pursue courses that are aligned with a particular career path. The electives required for this degree could count towards your concentration area. Please make sure to consult an advisor when choosing these courses.

## Special Electives (18 Units)

Students must take two special elective courses in the humanities and social sciences. The complete list of courses designated as special electives is available to current students at MyTepper (<http://mytepper.tepper.cmu.edu>). The list below is representative of the courses that qualify as "Special Electives"; this is not an exhaustive list of qualifying courses. In particular, the graduate courses from Heinz College which open to B.A. in Economics students are not presented.

## Course List

Representative List of Special Elective Courses		Units
19-402	Telecommunications Technology, Policy & Management	12
19-403	Policies of Wireless Systems	12
19-421	Emerging Energy Policies	9
19-424	Energy and the Environment	9
19-425	Sustainable Energy for the Developing World	9
79-221	Development and Democracy in Latin America	9
79-245	Capitalism and Individualism in American Culture	9
79-246	Industrial America	9
79-266	Russian History: From Communism to Capitalism	9
79-288	Bananas, Baseball, and Borders: Latin America and the United States	9
79-300	History of American Public Policy	9
79-310	Modern U. S. Business History: 1870 to the Present	9
79-320	Women, Politics, and Protest	9
79-371	African American Urban History	9
79-381	Energy and Empire: How Fossil Fuels Changed the World	9
79-386	Entrepreneurs in Africa, Past, Present and Future	9
79-392	History of Modern Warfare	9
80-130	Introduction to Ethics	9
80-136	Social Structure, Public Policy & Ethics	9
80-221	Philosophy of Social Science	9
80-305	Choices, Decisions, and Games	9
80-321	Causation, Law, and Social Policy	9
80-324	Philosophy of Economics	9
80-334	Social and Political Philosophy	9
80-337	Philosophy, Politics & Economics	9
80-348	Health Development and Human Rights	9
84-310	International Political Economy and Organizations	9
84-362	Diplomacy and Statecraft	9
84-386	The Privatization of Force	9
84-414	International and Subnational Security	9
88-411	Rise of the Asian Economies	9

Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)

	Units
73-497 Senior Project	9
or 73-500 Tepper College Honors Thesis I & 73-501 and Tepper College Honors Thesis II	
or 66-501 Dietrich College Senior Honors Thesis I & 66-502 and Dietrich College Senior Honors Thesis II	

## Sample Schedule for B.A. in Economics

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pursue additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually

the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	36-202 Methods for Statistics and Data Science	"Special Elective"	73-265 Economics and Data Science
73-102 Principles of Microeconomics	73-103 Principles of Macroeconomics	73-210 Economics Colloquium I	Economics Elective
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Junior		Senior	
Fall	Spring	Fall	Spring
73-270 Strategic Professional Communication for Economists	36-303 Sampling, Survey and Society	73-497 Senior Project	Economics Elective
"Special Elective"	Economics Elective	Economics Elective	-----
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\*In each semester, ----- represents courses that are not directly required for the major.

## B.S. in Economics

The B.S. in Economics provides a strong foundation in economic theory and advanced quantitative analysis. The curriculum focuses on using "real-world" data to forecast behavior and to investigate the relationships between observed phenomenon and economic models. Combining these sophisticated economic modeling data analytic skills with our wide range of upper-level economic electives provides students with a rigorous analytical foundation that will allow them to pursue any career that interests them. The capstone of the curriculum is the Senior Project course where students use their qualitative and quantitative skills to contribute to the body of knowledge in empirical, experimental, and/or theoretical studies. Students completing this degree will be well-equipped to pursue graduate work (professional and academic) or enter directly into the business world or public service.

All economics courses counting towards an economics degree must be completed with a grade of "C" or higher.

## B.S. in Economics Curriculum

**Total Number of Units for the Major 167/176**

## Mathematics Requirement (29 Units)

	Units
21-120 Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-256 Multivariate Analysis or 21-259 Calculus in Three Dimensions	9
21-122 Integration and Approximation * or 21-127 Concepts of Mathematics or 21-257 Models and Methods for Optimization	10
*Students are encouraged to meet with an economics advisor to determine which course best fits their interests	

## Sophomore Colloquium (3 UnitS)

	Units
73-210 Economics Colloquium I	3

## Quantitative Analysis Requirements (27 Units)

	Units
36-225 Introduction to Probability Theory or 36-217 Probability Theory and Random Processes or 21-325 Probability	9
73-274 Econometrics I	9
73-374 Econometrics II	9

**Writing Requirement (9 Units)**

		Units
73-270	Strategic Professional Communication for Economists	9

**Economic Theory Requirements (36 Units)**

		Units
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

**Advanced Economics Electives (54 Units)**

Students must take six advanced elective courses. Advanced elective courses are those numbered 73-300 through 73-495 (excluding 73-374 Econometrics II). For the purpose of these requirements, the Undergraduate Economics Program may also designate as advanced electives courses from other departments/programs.

Additionally, students may work with their advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability. Students have the option of earning a concentration (<http://mytepper.tepper.cmu.edu/current-students/undergraduate-students/economics/economics%20curriculum%20and%20courses>) by completing a set of interconnected electives. While a concentration area is not required for this degree, it is an additional option that allows students to pursue courses that are aligned with a particular career path. The electives required for this degree could count towards your concentration area. Please make sure to consult an advisor when choosing these courses.

**Senior Work (9 Units; 18 Units for students working on an honors thesis in economics)**

		Units
73-497	Senior Project	9
or 73-500 & 73-501	Tepper College Honors Thesis I and Tepper College Honors Thesis II	
or 66-501 & 66-502	Dietrich College Senior Honors Thesis I and Dietrich College Senior Honors Thesis II	

**Sample Course Schedule for the B.S. in Economics**

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; and 2) room has been built into the schedule that would allow students to pursue additional degrees and/or study abroad. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	73-240 Intermediate Macroeconomics
36-201 Statistical Reasoning and Practice	73-103 Principles of Macroeconomics	73-230 Intermediate Microeconomics	73-274 Econometrics I
73-102 Principles of Microeconomics	-----*	73-210 Economics Colloquium I	Economics Elective
-----	-----	Third Mathematics Course	-----
-----	-----	-----	-----
Junior		Senior	
Fall	Spring	Fall	Spring
73-270 Strategic Professional Communication for Economists	Economics Elective	73-497 Senior Project	Economics Elective
73-374 Econometrics II	Economics Elective	Economics Elective	-----
Economics Elective	-----	-----	-----
-----	-----	-----	-----
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\*In each semester, ----- represents courses not directly required for the major.

Program. Combining advanced mathematics with advanced economic theory is the hallmark of this curriculum. The curriculum provides students with courses that complement and develop depth of understanding of economic theory, applied economics, and applied mathematics. This degree offers an integrated curriculum, guiding students through a program of coursework that exploits and builds upon the synergies between mathematics and economics. This degree program equips students with the mathematical tools that are essential for success in Ph.D. programs in economics; mathematics; and key functional areas of business including finance, accounting, marketing, and information systems. Students pursuing this degree will be well prepared for the beginning of their research careers in academia, government, and industry. There are a limited number of student openings in this program; interested students may apply as early as their sophomore year. Acceptance into the degree program is based on academic performance, rigor of coursework, and initiative while at Carnegie Mellon. In order to graduate with the B.S. in Economics and Mathematical Sciences, students must maintain a cumulative Q.P.A. of 3.33.

All economics courses counting towards an economics degree must be completed with a grade of "C" or higher.

**B.S. in Economics and Mathematical Sciences Curriculum**

**Total Number of Units for the Major 239**

**Economic Theory Requirements (36 Units)**

		Units
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9

**Quantitative Analysis Requirements (45 Units)**

		Units
36-225	Introduction to Probability Theory	9
or 36-217	Probability Theory and Random Processes	
or 21-325	Probability	
36-226	Introduction to Statistical Inference	9
36-401	Modern Regression	9
73-274	Econometrics I	9
73-374	Econometrics II	9

**Mathematical Sciences Requirements (85 Units)**

		Units
21-120	Differential and Integral Calculus Passing the MCS assessment test is an acceptable alternative to completing 21-120.	10
21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-228	Discrete Mathematics	9-12
or 15-251	Great Ideas in Theoretical Computer Science	
21-241	Matrices and Linear Transformations	10
21-259	Calculus in Three Dimensions	9-10
or 21-256	Multivariate Analysis	
or 21-268	Multidimensional Calculus	
or 21-269	Vector Analysis	
21-260	Differential Equations	9
21-355	Principles of Real Analysis I	9
21-356	Principles of Real Analysis II	9

**Programming Requirement (10 Units)**

		Units
15-110	Principles of Computing	10

**Writing Requirement (9 Units)**

		Units
73-270	Strategic Professional Communication for Economists	9

**Advanced Economic Electives (27 Units)**

Students must take three advanced economics elective courses. Advanced Elective courses are those courses numbered 73-300 through 73-495, (excluding 73-374 Econometrics II) as well as courses designated by the Undergraduate Economics Program which are offered by other departments/programs. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements

**B.S. in Economics and Mathematical Sciences**

The B.S. in Economics and Mathematical Sciences is a collaborative effort between the Department of Mathematical Sciences and the Undergraduate Economics

based on their particular interests, subject to course availability. Students have the option of earning a concentration (<http://mytepper.tepper.cmu.edu/current-students/undergraduate-students/economics/economics%20curriculum%20and%20courses>) by completing a set of interconnected electives. While a concentration area is not required for this degree, it is an additional option that allows students to pursue courses that are aligned with a particular career path. The electives required for this degree could count towards your concentration area. Please make sure to consult an advisor when choosing these courses.

#### Recommended Advanced Economics Electives:

73-315	Market Design	9
73-338	Financial Crises and Risk	9
73-347	Game Theory for Economists	9
73-365	Firms, Market Structures, and Strategy	9
73-421	Emerging Markets	9

#### Mathematical Science Depth Electives (27 Units)

Students must take three advanced mathematics depth courses. Students are encouraged to work with their advisors to structure a set of courses which meet these requirements based on their particular interests, subject to course availability.

#### Recommended Mathematical Science Depth Electives:

21-292	Operations Research I	9
21-329	Set Theory	9
21-365	Projects in Applied Mathematics	9
21-366	Topics in Applied Mathematics	9
21-371	Functions of a Complex Variable	9
21-374	Field Theory	9
21-441	Number Theory	9
21-484	Graph Theory	9
21-499	Undergraduate Research Topic	9

Note: Only one of the following three courses may count towards the required Mathematical Sciences Depth Electives: 21-365, 21-366, or 21-499.

#### Sample Course Schedule for the B.S. in Economics and Mathematical Sciences

The sample schedule below is an illustration of how students might plan their four-year schedules. This schedule has been designed to highlight the following characteristics of the degree program: 1) the work load is roughly 45-50 units per semester, hence there is no need for course overloading; 2) room has built into the schedule that would allow students to pursue additional degrees and/or study abroad; and 3) the demands of this degree require students to carefully plan their degree program while keeping in mind the college-level and university-level graduation requirements. It is important for students to realize that degree requirements are the actually the "minimum" set of degree requirements. In fact, most economics students take more courses in their major than is strictly required.

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	15-110 Principles of Computing	21-122 Integration and Approximation	21-241 Matrices and Linear Transformations
36-201 Statistical Reasoning and Practice	21-256 Multivariate Analysis	21-127 Concepts of Mathematics	36-226 Introduction to Statistical Inference
73-102 Principles of Microeconomics	73-103 Principles of Macroeconomics	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
-----*	-----	36-225 Introduction to Probability Theory	73-274 Econometrics I
-----	-----	-----	Economics Elective

Junior		Senior	
Fall	Spring	Fall	Spring
21-260 Differential Equations	21-355 Principles of Real Analysis I	21-228 Discrete Mathematics	21-356 Principles of Real Analysis II
73-374 Econometrics II	Economics Elective	36-401 Modern Regression	-----
73-270 Strategic Professional Communication for Economists	Mathematics Elective	Mathematics Elective	-----
Economics Elective	-----	-----	-----
Mathematics Elective	-----	-----	-----

\*In each semester, ----- represents courses not directly required for the major. Please note that students pursuing the B.S. in Mathematical Sciences and Economics must fulfill the Mellon College General Education requirements and not the Dietrich College General Education requirements.

## B.S. in Economics and Statistics

Academic Advisor: Samantha Nielsen  
 Faculty Advisors: Rebecca Nugent and Edward Kennedy  
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The Major in Economics and Statistics provides an interdisciplinary course of study aimed at students with a strong interest in the empirical analysis of economic data. With joint curriculum from the Department of Statistics and Data Science and the Undergraduate Economics Program, the major provides students with a solid foundation in the theories and methods of both fields. Students in this major are trained to advance the understanding of economic issues through the analysis, synthesis and reporting of data using the advanced empirical research methods of statistics and econometrics. Graduates are well positioned for admission to competitive graduate programs, including those in statistics, economics and management, as well as for employment in positions requiring strong analytic and conceptual skills - especially those in economics, finance, education, and public policy.

All economics courses counting towards an economics degree must be completed with a grade of "C" or higher.

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

### I. Prerequisites 18-39 units

#### 1. Mathematical Foundations 38-39 units

##### Calculus

21-120	Differential and Integral Calculus	10
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and *one* of the following three:

21-122	Integration and Approximation	10
21-127	Concepts of Mathematics	10
21-257	Models and Methods for Optimization	9

and *one* of the following:

21-256	Multivariate Analysis	9
21-259	Calculus in Three Dimensions	9

**Note:** Passing the MSC 21-120 assessment test is an acceptable alternative to completing 21-120.

**Note:** Taking both 21-111 and 21-112 is equivalent to 21-120. The Mathematical Foundations total is then 48-49 units. The Economics and Statistics major would then total 201-211 units.

##### Linear Algebra

*One* of the following three courses:

21-240	Matrix Algebra with Applications	10
21-241	Matrices and Linear Transformations	10
21-242	Matrix Theory	10

**Note:** 21-241 and 21-242 are intended only for students with a very strong mathematical background.

### II. Foundations 18-36 units

#### 2. Economics Foundations 18 units

73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9

#### 3. Statistical Foundations 9-18 units

Sequence 1 (For students beginning their freshman or sophomore year)

##### Beginning\*

Choose *one* of the following courses

36-200	Reasoning with Data	9
36-201	Statistical Reasoning and Practice	9
36/70-207	Probability and Statistics for Business Applications	9
36-220	Engineering Statistics and Quality Control	9
36-247	Statistics for Lab Sciences	9

\*Or extra data analysis course in Statistics

Note: Students who enter the program with 36-225 or 36-226 should discuss options with an advisor. Any 36-300 or 36-400 level course in Data Analysis that does not satisfy any other requirement for the Economics and Statistics Major may be counted as a Statistical Elective.

#### Intermediate\*

Choose *one* of the following courses:

36-202	Methods for Statistics and Data Science **	9
36-208	Regression Analysis	9
36-309	Experimental Design for Behavioral and Social Sciences	9

\*Or extra data analysis course in Statistics

\*\*Must take prior to 36-401

Sequence 2 (For students beginning later in their college career)

#### Advanced

Choose *one* of the following courses:

36-303	Sampling, Survey and Society	9
36-315	Statistical Graphics and Visualization	9
36-461	Special Topics: Statistical Methods in Epidemiology	9
36-462	Special Topics: Data Mining	9
36-463	Special Topics: Multilevel and Hierarchical Models	9
36-464	Special Topics: Applied Multivariate Methods	9
36-490	Undergraduate Research	9

\*\*Special Topics rotate and new ones are regularly added.

### III. Disciplinary Core 126 units

#### 1. Economics Core 45 units

73-230	Intermediate Microeconomics	9
73-240	Intermediate Macroeconomics	9
73-270	Strategic Professional Communication for Economists	9
73-274	Econometrics I	9
73-374	Econometrics II	9

#### 2. Statistics Core 36 units

36-225	Introduction to Probability Theory **	9
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and *one* of the following two courses:

36-226	Introduction to Statistical Inference *	9
36-326	Mathematical Statistics (Honors) *	9

and *both* of the following two courses:

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

\*In order to be a major in good standing, a grade of C or better is required in 36-225 (or equivalents), 36-226 or 36-326 and 36-401. Otherwise you will not be allowed to continue in the major.

#It is possible to substitute 36-217 or 21-325 for 36-225. (36-225 is the standard introduction to probability, 36-217 is tailored for engineers and computer scientists, and 21-325 is a rigorous Probability Theory course offered by the Department of Mathematics.)

#### 3. Computing 9 units

36-350	Statistical Computing *	9
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\*In rare circumstances, a higher level Statistical Computing course, approved by your Statistics advisor, may be used as a substitute.

#### 4. Advanced Electives 36 units

Students must take two advanced Economics elective courses (numbered 73-300 through 73-495, excluding 73-374) and two advanced Statistics elective courses (numbered 36-303, 36-315, or 36-410 through 36-495).

Students pursuing a degree in Economics and Statistics also have the option of earning a concentration area by completing a set of interconnected electives. While a concentration area is not required for this degree, this is an additional option that

allows students to pursue courses that are aligned with a particular career path. The two electives that are already required for this degree could count towards your concentration area, please make sure to consult an advisor when choosing these courses.

<b>Total number of units for the major</b>	<b>191-201 units</b>
<b>Total number of units for the degree</b>	<b>360 units</b>

### Professional Development

Students are strongly encouraged to take advantage of professional development opportunities and/or coursework. One option is 73-210 Economics Colloquium I, a fall-only course that provides information about careers in Economics, job search strategies, and research opportunities. The Department of Statistics and Data Science also offers a series of workshops pertaining to resume preparation, graduate school applications, careers in the field, among other topics. Students should also take advantage of the Career and Professional Development Center.

### Additional Major in Economics and Statistics

Students who elect Economics and Statistics as a second or third 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 and three Statistics) that do not count for their primary major. If students do not have at least six, they typically take additional advanced electives.

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.

Many departments require Statistics courses as part of their Major or Minor programs. Students seeking transfer credit for those requirements from substitute courses (at Carnegie Mellon or elsewhere) should seek permission from their advisor in the department setting the requirement. The final authority in such decisions rests there. The Department of Statistics and Data Science does not provide approval or permission for substitution or waiver of another department's requirements.

If a waiver or substitution is made in the home department, it is not automatically approved in the Department of Statistics and Data Science. In many of these cases, the student will need to take additional courses to satisfy the Economics and Statistics major requirements. Students should discuss this with a Statistics advisor when deciding whether to add an additional major in Economics and Statistics.

### 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).

Freshman		Sophomore	
Fall	Spring	Fall	Spring
21-120 Differential and Integral Calculus	36-202 Methods for Statistics and Data Science	21-122 Integration and Approximation **	21-240 Matrix Algebra with Applications
36-200 Reasoning with Data	21-256 Multivariate Analysis	36-225 Introduction to Probability Theory	36-226 Introduction to Statistical Inference
73-102 Principles of Microeconomics	73-103 Principles of Macroeconomics	73-230 Intermediate Microeconomics	73-240 Intermediate Macroeconomics
----*	----	----	73-274 Econometrics I
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Junior		Senior	
Fall	Spring	Fall	Spring
36-350 Statistical Computing	36-402 Advanced Methods for Data Analysis	Statistics Elective	Economics Elective
36-401 Modern Regression	73-270 Strategic Professional Communication for Economists	Economics Elective	Statistics Elective
73-374 Econometrics II	----	----	----
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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.

\*\* Students can also take 21-127 or 21-257. Students should consult with their advisor.

Prospective PhD students might 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.

## Supplemental Programs

### Honors Program in Economics

Outstanding students are eligible for the honors programs in both the Tepper School of Business and the Dietrich College of Humanities and Social Sciences. For more information, consult the Dietrich Honors Program website (<http://www.cmu.edu/dietrich/undergraduate/programs/shp>).

The Tepper Senior Honors Program in Economics (<http://tepper.cmu.edu/prospective-students/undergraduate/economics/curriculum/research/senior-honors-program>) provides qualified students with the opportunity to engage in original research during their senior year at Carnegie Mellon. The primary rewards of participating in the Honors Program in Economics are three-fold. First comes the satisfaction of undertaking and completing an original piece of research. Working independently or with a faculty member to identify a research question and claim ownership of its discovery process is a rewarding experience. Second is the opportunity to challenge oneself intellectually. The third advantage is the opportunity to graduate with Tepper Honors. For many, this process of intellectual inquiry and knowledge creation is the highlight and culmination of their undergraduate academic experience.

Students are invited into the Tepper Senior Honors Program in Economics during their junior year. Invitation is based on academic achievement at Carnegie Mellon University, ability to work independently, and tenacity of spirit.

### Accelerated Master's Degree Programs

Accelerated Master's Degree programs enable exceptional students to earn both an undergraduate degree and a masters degree by remaining one additional year at Carnegie Mellon. The Heinz College of Public Policy and Management offers four professional accelerated masters degree programs: a Master of Science in Arts Administration (<http://www.heinz.cmu.edu/school-of-public-policy-management/arts-management-mam>), Master of Science of Health Care and Policy Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/healthcare-policy-management-hcpm>), Master of Information Systems Management (<http://www.heinz.cmu.edu/school-of-information-systems-and-management/information-systems-management-mism>), and Master of Science in Public Policy and Management (<http://www.heinz.cmu.edu/school-of-public-policy-management/public-policy-management-msppm>). The Tepper School of Business offers one accelerated professional degree, a Master in Business Administration.

## Dual Degree in Economics

A student pursuing a primary degree outside of the department may obtain a dual degree by completing all of the requirements for the B.S. in Economics or the B.S. in Economics and Statistics along with the Dietrich College general education requirements. In addition, the student's total units completed must be at least 90 units in excess of the requirement for the student's other degree(s) or at least 450 units, whichever is greater. Interested students should meet with an economics advisor.

## Additional Major in Economics Curriculum

All university students are eligible to pursue an additional major in economics in conjunction with a major in any department in the university other than economics. The requirements for the Additional Major in Economics are the same as those for the B.S. in Economics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing an Additional Major in Economics are asked to take additional advanced economics electives.

## Additional Major in Economics and Statistics Curriculum

All university students are eligible to pursue a major in economics and statistics in conjunction with a major in any department in the university other than statistics or economics. The requirements for the Additional Major in Economics in Statistics are the same as those for the B.S. in Economics and Statistics, except that the Dietrich College General Education requirements are waived. In order to avoid "double counting" issues, students are encouraged to meet with an economics or statistics advisor. When courses are shared across degrees, students pursuing an Additional

Major in Economics and Statistics are asked to take additional advanced economics or statistics electives.

## Minor in Economics

The Minor in Economics degree program provides students with a solid understanding of economic theory and data analysis.

All university students are eligible to pursue the Minor in Economics in conjunction with a major in any other department in the university. In order to avoid "double counting" issues, students are encouraged to meet with an economics advisor. When courses are shared across degrees, students pursuing a minor in Economics are asked to take additional advanced economics electives.

All economics courses counting towards the minor must be completed with a grade of "C" or higher.

**Minor in Economics (Total Number of Units for the Minor: 73/82)**

### Mathematics Requirements (10 Units)

		Units
21-120	Differential and Integral Calculus	10

### Economic Theory Requirements (27 Units)

		Units
73-102	Principles of Microeconomics	9
73-103	Principles of Macroeconomics	9
73-160	Foundations of Microeconomics: Applications and Theory*	9

\*Students may choose to replace 73-160 with 73-230 Intermediate Microeconomics or 73-240 Intermediate Macroeconomics. Most of the advanced economics electives require 73-230 and/or 73-240. Please note that 21-256 is a pre-requisite for 73-230.

### Quantitative Analysis Requirements (18/27 Units)

The quantitative analysis path is often determined by the major requirements. The sequence is designed to give students an understanding of probability theory, regression analysis, and quantitative economic analysis. Students are encouraged to talk with an economics advisor to determine which requirements best complement their primary fields of study.

		Units
Option One		
36-201	Statistical Reasoning and Practice	9
or 36-200	Reasoning with Data	
36-202	Methods for Statistics and Data Science	9
or 36-309	Experimental Design for Behavioral and Social Sciences	
73-265	Economics and Data Science	9
Option Two		
70/36-207	Probability and Statistics for Business Applications	9
70/36-208	Regression Analysis	9
73-265	Economics and Data Science	9
Option Three		
36-220	Engineering Statistics and Quality Control	9
73-265	Economics and Data Science	9
Option Four		
36-217	Probability Theory and Random Processes	9
or 36-225	Introduction to Probability Theory	
36-202	Methods for Statistics and Data Science	9
or 36-309	Experimental Design for Behavioral and Social Sciences	
or 36-226	Introduction to Statistical Inference	
73-265	Economics and Data Science	9

### Advanced Economics Electives (18 Units)

Students must take two advanced elective courses. Advanced elective courses are those numbered 73-3xx through 73-49x (excluding 73-374 Econometrics II) as well as courses designated by the program offered by other departments/programs. Additionally, students may work with their economics advisor to structure alternative sets of courses to meet these requirements based on their particular interests, subject to course availability.

## Faculty

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## Adjunct Faculty

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