Undergraduate Economics Program

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http://tepper.cmu.edu/prospective-students/undergraduate/economics

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, and in analyzing 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, Marriana 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 visit the program website (https://www.cmu.edu/tepper/programs/undergraduate-economics/curriculum).

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 courses is invited to meet with an economics advisor. To facilitate scheduling advising meetings, please use the online appointment scheduler (https://meetme.so/CMUEconomics).

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 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 are available.

Concentrations

The Undergraduate Economics Program offers six concentration areas which allow students to specialize in:

- Advanced Quantitative Economic Methods: For students considering a career in international finance, central banking or macroeconomic consulting, this area explores the role of financial crises, the role of the Federal Reserve in the economy, and the determination of exchange and interest rates.
- Economics of Global Change and Disruption: Gain an understanding of global climate change, economic development, and technological change — as an essential foundation for a career in international finance, central banking or macroeconomic consulting, this area explores the role of financial crises, the role of the Federal Reserve in the economy, and the determination of exchange and interest rates.
- Economics of Strategic Consulting, Public Policy, or International Organizations such as the IMF or World Bank.
- Market Design: For tech firms, consultancies, and many areas of business and public policy, market design — the new frontier of economics — is the key to success. Here, you’ll explore why market arrangements succeed or fail, and how markets might be better designed.

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 (https://www.cmu.edu/tepper/programs/undergraduate-economics/curriculum) 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 actual and 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 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

<table>
<thead>
<tr>
<th>Total Number of Units for the Major:</th>
<th>157/166</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Prerequisites (19 units)</td>
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<tr>
<td>Courses</td>
<td>Units</td>
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<tr>
<td>21-120 Differential and Integral Calculus</td>
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<tr>
<td>21-256 Multivariate Analysis</td>
<td>9</td>
</tr>
<tr>
<td>Sophomore Economics Colloquim (3 units)</td>
<td>Units</td>
</tr>
<tr>
<td>73-210 Economics Colloquim I</td>
<td>3</td>
</tr>
<tr>
<td>Writing Requirement (9 units)</td>
<td>Units</td>
</tr>
<tr>
<td>73-270 Strategic Professional Communication for Economists</td>
<td>9</td>
</tr>
<tr>
<td>Economic Theory Requirements (36 units)</td>
<td>Units</td>
</tr>
<tr>
<td>73-102 Principles of Microeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-103 Principles of Macroeconomics</td>
<td>9</td>
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</tbody>
</table>
73-230 Intermediate Microeconomics 9
73-240 Intermediate Macroeconomics 9

Quantitative Analysis Requirements (27 Units)

<table>
<thead>
<tr>
<th>Units</th>
<th>Subject</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>9</td>
<td></td>
<td>36-200 Reasoning with Data</td>
</tr>
<tr>
<td></td>
<td>or 36-207 Probability and Statistics for Business Applications</td>
<td></td>
</tr>
<tr>
<td></td>
<td>or 70-207 Probability and Statistics for Business Applications</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>73-265 Economics and Data Science</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>73-274 Econometrics I</td>
<td></td>
</tr>
</tbody>
</table>

Advanced Economics Electives (36 Units)

Students must take four advanced elective courses. Advanced elective courses are numbered 73-300 through 73-495. 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 (https://www.cmu.edu/tepper/programs/undergraduate-economics/curriculum) 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. Students will receive a list of courses designated as special electives each semester. The list below is representative of the courses that qualify as "Special Electives"; this is not an exhaustive list of qualifying courses.

Course List

<table>
<thead>
<tr>
<th>Representative List of Special Elective Courses</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>19-402 Telecommunications Technology and Policy for the Internet Age</td>
<td>12</td>
</tr>
<tr>
<td>19-403 Policies of Wireless Systems</td>
<td>12</td>
</tr>
<tr>
<td>19-421 Emerging Energy Policies</td>
<td>9</td>
</tr>
<tr>
<td>19-424 Energy and the Environment</td>
<td>9</td>
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<tr>
<td>19-425 Sustainable Energy for the Developing World</td>
<td>9</td>
</tr>
<tr>
<td>66-221 Topics of Law: Introduction to Intellectual Property Law</td>
<td>9</td>
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<tr>
<td>79-221 Development and Democracy in Latin America</td>
<td>9</td>
</tr>
<tr>
<td>79-236 Coming to America: The View from New York City, Past and Present</td>
<td>6</td>
</tr>
<tr>
<td>79-245 Capitalism and Individualism in American Culture</td>
<td>9</td>
</tr>
<tr>
<td>79-255 Industrial America</td>
<td>9</td>
</tr>
<tr>
<td>79-266 Russian History: From Communism to Capitalism</td>
<td>9</td>
</tr>
<tr>
<td>79-280 Bananas, Baseball, and Borders: Latin America and the United States</td>
<td>9</td>
</tr>
<tr>
<td>79-300 History of American Public Policy</td>
<td>9</td>
</tr>
<tr>
<td>79-310 Modern U.S. Business History: 1870 to the Present</td>
<td>9</td>
</tr>
<tr>
<td>79-315 Thirsty Planet: The Politics of Water in Global Perspective</td>
<td>9</td>
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<tr>
<td>79-320 Women, Politics, and Protest</td>
<td>9</td>
</tr>
<tr>
<td>79-343 Education, Democracy, and Civil Rights</td>
<td>9</td>
</tr>
<tr>
<td>79-371 African American Urban History</td>
<td>9</td>
</tr>
<tr>
<td>79-381 Energy and Empire: How Fossil Fuels Changed the World</td>
<td>9</td>
</tr>
<tr>
<td>79-386 Entrepreneurs in Africa, Past, Present and Future</td>
<td>9</td>
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<tr>
<td>79-392 America at War: From Vietnam to Afghanistan</td>
<td>9</td>
</tr>
<tr>
<td>80-130 Introduction to Ethics</td>
<td>9</td>
</tr>
<tr>
<td>80-136 Social Structure, Public Policy &amp; Ethics</td>
<td>9</td>
</tr>
<tr>
<td>80-221 Philosophy of Social Science</td>
<td>9</td>
</tr>
<tr>
<td>80-249 AI, Society, and Humanity</td>
<td>9</td>
</tr>
<tr>
<td>80-305 Choices, Decisions, and Games</td>
<td>9</td>
</tr>
<tr>
<td>80-335 Social and Political Philosophy</td>
<td>9</td>
</tr>
<tr>
<td>80-348 Health, Development, and Human Rights</td>
<td>9</td>
</tr>
<tr>
<td>84-310 International Political Economy</td>
<td>9</td>
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<tr>
<td>84-318 Politics of Developing Nations</td>
<td>9</td>
</tr>
<tr>
<td>84-362 Diplomacy and Statecraft</td>
<td>9</td>
</tr>
<tr>
<td>84-386 The Privatization of Force</td>
<td>9</td>
</tr>
</tbody>
</table>

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)

21-120 Differential and Integral Calculus 10

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

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

Sophomore Colloquium (3 Units)

73-210 Economics Colloquium I 3

Quantitative Analysis Requirements (27 Units)

73-265 Economics and Data Science 9
73-274 Econometrics I 9
73-374 Econometrics II 9

Writing Requirement (9 Units)

73-270 Strategic Professional Communication for Economists 9

Economic Theory Requirements (36 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). 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 (https://www.cmu.edu/tepper/
programs/undergraduate-economics/curriculum) 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)

73-497 Senior Project 9
or 73-500 Tepper College Honors Thesis I
& 73-501 and Tepper College Honors Thesis II
or 66-501 H&SS Senior Honors Thesis I
& 66-502 and H&SS 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.

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Sophomore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
</tr>
<tr>
<td>36-200 Reasoning with Data</td>
<td>36-205 Econometrics and Data Science</td>
</tr>
<tr>
<td>21-256 Multivariate Analysis</td>
<td>73-305 Intermediate Microeconomics</td>
</tr>
<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>73-205 Intermediate Macroeconomics</td>
</tr>
<tr>
<td>73-102 Principles of Microeconomics</td>
<td>73-274 Econometrics I</td>
</tr>
<tr>
<td>73-060 Economics: BaseCamp</td>
<td>21-240 Matrix Algebra with Applications</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Spring</td>
</tr>
<tr>
<td>73-270 Strategic Professional Communication for Economists</td>
<td>73-497 Senior Project</td>
</tr>
<tr>
<td>73-374 Econometrics II</td>
<td>Economics Elective</td>
</tr>
<tr>
<td>73-240 Intermediate Macroeconomics</td>
<td>Economics Elective</td>
</tr>
</tbody>
</table>

*In each semester, ----- represents courses not directly required for the major.

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 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)

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)

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
Mathematical Sciences Requirements (85 Units)

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
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<tbody>
<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>10</td>
</tr>
<tr>
<td>21-122 Integration and Approximation</td>
<td>10</td>
</tr>
<tr>
<td>21-127 Concepts of Mathematics</td>
<td>10</td>
</tr>
<tr>
<td>or 21-228 Discrete Mathematics</td>
<td>9-12</td>
</tr>
<tr>
<td>or 15-251 Great Ideas in Theoretical Computer Science</td>
<td></td>
</tr>
<tr>
<td>21-241 Matrices and Linear Transformations</td>
<td>10</td>
</tr>
<tr>
<td>21-259 Calculus in Three Dimensions</td>
<td>9-10</td>
</tr>
<tr>
<td>or 21-256 Multivariate Analysis</td>
<td></td>
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<tr>
<td>or 21-268 Multidimensional Calculus</td>
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<tr>
<td>or 21-269 Vector Analysis</td>
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<tr>
<td>21-260 Differential Equations</td>
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<tr>
<td>21-355 Principles of Real Analysis I</td>
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<tr>
<td>21-356 Principles of Real Analysis II</td>
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Programming Requirement (10 Units)

<table>
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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>15-110 Principles of Computing</td>
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</table>

Writing Requirement (9 Units)

<table>
<thead>
<tr>
<th>Course</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>73-270 Strategic Professional Communication for Economists</td>
<td>9</td>
</tr>
</tbody>
</table>

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 I. 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. Students have the option of earning a concentration (https://www.cmu.edu/tepper/programs/undergraduate-economics-curriculum) 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
- 73-338 Financial Crises and Risk
- 73-347 Game Theory for Economists
- 73-365 Firms, Market Structures, and Strategy
- 73-421 Emerging Markets

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

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

<table>
<thead>
<tr>
<th>Semester</th>
<th>Freshman</th>
<th>Sophomore</th>
<th>Junior</th>
<th>Senior</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>or 21-268 Multidimensional Calculus</td>
<td>or 21-269 Vector Analysis</td>
<td>or 73-313 Intermediate Microeconomics</td>
<td>or 36-200 Reasoning with Data</td>
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<td>or 21-269 Vector Analysis</td>
<td>or 21-269 Vector Analysis</td>
<td>or 73-320 Introduction to Microeconomics</td>
<td>or 73-313 Intermediate Microeconomics</td>
</tr>
<tr>
<td></td>
<td>21-356 Principles of Real Analysis II</td>
<td>21-356 Principles of Real Analysis II</td>
<td>36-401 Modern Regression</td>
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<tr>
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<td>73-374 Econometrics II</td>
<td>73-374 Econometrics II</td>
<td>73-370 Strategic Professional Communication for Economists</td>
<td>73-370 Strategic Professional Communication for Economists</td>
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<td>Economics Elective</td>
<td>Economics Elective</td>
<td>Mathematics Elective</td>
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<td>Mathematics Elective</td>
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</table>

*In each semester, ----- represents courses not directly required for the major. Please note that students pursing 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

**Executive Director, Undergraduate Economics Program:** Carol Goldberg

**Senior Academic Advisor and Program Manager, Undergraduate Economics Program:** Kathleen Conway

**Office:** Baker Hall 132

**Email:** statadvising@stat.cmu.edu

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**

- **38-39 units**
  - **1. Mathematical Foundations**
    - **38-39 units**
    - **Calculus**: 21-120 Differential and Integral Calculus
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
36/70-207 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 Statistics & Data Science Methods ** 9
36-208 Regression Analysis 9
36-290 Introduction to Statistical Research Methodology 9
36-309 Experimental Design for Behavioral & 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
36-311 Statistical Analysis of Networks 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
36-466 Special Topics: Statistical Methods in Finance 9
36-467 Special Topics: Data over Space & Time 9
36-490 Undergraduate Research 9

Special Topics rotate and new ones are regularly added.

### III. Disciplinary Core 126 units

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>73-230</td>
<td>Intermediate Microeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-240</td>
<td>Intermediate Macroeconomics</td>
<td>9</td>
</tr>
<tr>
<td>73-270</td>
<td>Strategic Professional Communication for Economists</td>
<td>9</td>
</tr>
<tr>
<td>73-265</td>
<td>Economics and Data Science</td>
<td>9</td>
</tr>
<tr>
<td>73-274</td>
<td>Econometrics I</td>
<td>9</td>
</tr>
<tr>
<td>73-374</td>
<td>Econometrics II</td>
<td>9</td>
</tr>
</tbody>
</table>

2. Statistics Core 36 units

36-225 Introduction to Probability Theory *# 9
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

*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, 36-311, 36-315, or 36-46x 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.

### Total number of units for the major 191-201 units

### Total number of units for the degree 360 units

### 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 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).

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Sophomore</th>
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<tbody>
<tr>
<td><strong>Fall</strong></td>
<td><strong>Spring</strong></td>
</tr>
<tr>
<td>21-120 Differential and Integral Calculus</td>
<td>36-200 Reasoning with Data</td>
</tr>
<tr>
<td>36-200 Multivariate Analysis</td>
<td>73-102 Principles of Microeconomics</td>
</tr>
<tr>
<td>73-040 Economics: BaseCamp <em>not required</em></td>
<td>73-265 Economics and Data Science</td>
</tr>
</tbody>
</table>
| *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 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-administration), Master of Science in 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-mpspm). 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

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

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 and 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

In addition to preparing students to be better informed global citizens and consumers, the Minor in Economics provides students with the economic and data analytical toolkit that is the foundation of business/organizational decision-making.

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
Undergraduate Economics Program

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: 82)

Mathematics Requirements (10 Units)
21-120  Differential and Integral Calculus  10

Economic Theory Requirements (27 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 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.

Option One

36-200  Reasoning with Data  9
or 36-207  Probability and Statistics for Business Applications  9
73-265  Economics and Data Science  9

Option Two

36-220  Engineering Statistics and Quality Control  9
73-265  Economics and Data Science  9

Option Three

36-217  Probability Theory and Random Processes  9
or 36-225  Introduction to Probability Theory  9
73-265  Economics and Data Science  9

Advanced Economics Electives (27 Units)
Students must take three advanced elective courses. Advanced elective courses are those numbered 73-xxx through 74-49x. 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

LAURENCE ALES, Associate Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2008-

KATHARINE ANDERSON, Assistant Professor of Economics and Entrepreneurship – Ph.D., University of Michigan; Carnegie Mellon, 2010-

JAMES A. BEST, Assistant Professor of Economics – Ph.D., University of Edinburgh; Carnegie Mellon, 2018-

AISLINN BOHREN, Assistant Professor of Economics – Ph.D., University of California, San Diego; Carnegie Mellon, 2018-

STEPHEN M. CALABRESE, Visiting Associate Professor of Economics, Carnegie Mellon University-Qatar – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2007-

DAVID CHILDERS, Assistant Professor of Economics – Ph.D., Yale University; Carnegie Mellon, 2016-

KAREN B. CLAY, Professor of Economics and Public Policy, H. J. Heinz III College – Ph.D., Stanford University; Carnegie Mellon, 1998-

ROBERT M. DAMMON, Dean; Professor of Financial Economics – Ph.D., University of Wisconsin; Carnegie Mellon, 1984-

TIMOTHY P. DERDINGER, Associate Professor of Marketing and Strategy – Ph.D., University of Southern California; Carnegie Mellon, 2009-

KENNETH B. DUNN, Professor of Financial Economics, Emeritus – Ph.D., Purdue University; Carnegie Mellon, 1979-

DENNIS N. EPPLER, Thomas Lord University Professor of Economics – Ph.D., Princeton University; Carnegie Mellon, 1974-

SELMAN EROL, Assistant Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 2016-

CHRISTINA FONG, Senior Research Scientist in Social and Decision Sciences, Dietrich College of Humanities and Social Sciences – Ph.D., University of Massachusetts; Carnegie Mellon, 2001-

JOHN GASPER, Associate Teaching Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2010-

MARTIN GAYNOR, E.J. Barone University Professor of Economics and Health Policy, H. J. Heinz III College – Ph.D., Northwestern University; Carnegie Mellon, 1999-

MARRI V. GOODFRIEND, Friends of Allan Meltzer Professorship; Professor of Economics – Ph.D., Brown University; Carnegie Mellon, 2005-

BURTON HOLLIFIELD, Head, B.S. in Business Administration Program, PNC Professor of Finance; Professor of Financial Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 1999-

KARAM KANG, Assistant Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 2012-

ONUR KESTEN, Associate Professor of Economics – Ph.D., University of Rochester; Carnegie Mellon, 2005-

ALEXEY KUSHNIR, Assistant Professor of Economics – Ph.D., Pennsylvania State University; Carnegie Mellon, 2014-

FINN KYDLAND, The Richard P. Simons Distinguished Professorship; University Professor of Economics; Nobel Laureate (2004) - Ph.D., Carnegie Mellon University; Carnegie Mellon, 1977-

REBECCA LESSEM, Assistant Professor of Economics – Ph.D., University of Wisconsin-Madison; Carnegie Mellon, 2011-

BENNETT T. MCCALLUM, H. J. Heinz Professor of Economics, Emeritus – Ph.D., Rice University; Carnegie Mellon, 1981-

ROBERT A. MILLER, Richard M. Cyert and Morris DeGroot Professor of Economics and Statistics – Ph.D., University of Chicago; Carnegie Mellon, 1982-

NICHOLAS MULLER, Associate Professor of Economics, Engineering, and Public Policy – Ph.D., Yale University; Carnegie Mellon, 2017-

ANH NGUYEN, Assistant Professor of Economics – Ph.D., Columbia University; Carnegie Mellon, 2018-

JOHN R. O’BRIEN, Associate Dean, Carnegie Mellon University-Qatar; Associate Professor of Accounting and Experimental Economics – Ph.D., University of Minnesota; Carnegie Mellon, 1984-

MARYAM SAEDI, Assistant Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2016-

ALI SHOURIDEH, Assistant Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2016-

CHRISTOPHER SLEET, Head, Economics Programs, Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005-

FALLAW B. SOWELL, Associate Professor of Economics – Ph.D., Duke University; Carnegie Mellon, 1988-

CHESTER S. SPATT, Pamela R. and Kenneth B. Dunn Professor of Finance – Ph.D., University of Pennsylvania; Carnegie Mellon, 1979-

STEPHEN E. SPEAR, Professor of Economics – Ph.D., University of Pennsylvania; Carnegie Mellon, 1982-

V. EMILY STARK, Assistant Teaching Professor of Business Communications – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2013-

CHRISTOPHER I. TELMER, Associate Professor of Financial Economics – Ph.D., Queen’s University (Canada); Carnegie Mellon, 1992-

SHU LIN WEE, Assistant Professor of Economics – Ph.D., University of Maryland; Carnegie Mellon, 2014-

SEVIN YELTEKIN, Senior Associate Dean, Education; Professor of Economics – Ph.D., Stanford University; Carnegie Mellon, 2005-

ARIEL ZETLIN-JONES, Associate Professor of Economics – Ph.D., University of Minnesota; Carnegie Mellon, 2012-
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MARGARITA PORTNYKH, Postdoctoral Fellow in Economics – Ph.D., Clemson University; Carnegie Mellon, 2018-
BERTAN TURHAN, Visiting Assistant Professor of Economics – Ph.D., Boston College; Carnegie Mellon, 2018-

Adjunct Faculty
CAROL B. GOLDBURG, Executive Director, Undergraduate Economics Program; Adjunct Professor of Economics – Ph.D., Carnegie Mellon University; Carnegie Mellon, 2005-