

# MATHEMATICAL ECONOMICS

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Mathematics and economics are complementary disciplines. Most branches of modern economics use mathematics and statistics extensively, and some important areas of mathematical research have been motivated by economic problems. Economists and mathematicians have made important contributions to one another's disciplines. Economist Kenneth Arrow, for example, did path-breaking work in the field of mathematical optimization, and in 1994, Mathematician John Nash was awarded the Nobel Prize in economics for work he did in game theory that has become central to contemporary economic theory. Haverford's Area of Concentration in Mathematical Economics enables students in both disciplines not only to gain proficiency in the other, but also to appreciate the ways in which they are related.

Economics students with a variety of backgrounds and career interests can benefit from completing the concentration. The mathematics courses the concentration requires are extremely valuable for students interested in pursuing graduate study in economics. A strong mathematical background is also an asset for students going on to business school or graduate programs in public policy. Many economics-related jobs in government, business, and finance require strong quantitative skills, and the concentration prepares students interested in seeking such positions.

The concentration can also benefit mathematics majors. Many students find mathematics more exciting and meaningful when they see it applied to a discipline they find interesting and concrete. Almost every undergraduate mathematics course covers topics useful in economic applications: optimization techniques in multivariable calculus, quadratic forms in linear algebra, and fixed point theorems in topology. In intermediate and advanced courses in economics, mathematics majors can see how these tools and methods are applied in another discipline.

## LEARNING GOALS

Students in Area of Concentration in Mathematical Economics will:

- engage in theoretical and empirical analysis of economic problems using formal theoretical

and empirical methods.

- develop tools and techniques, including the use of formal arguments, numerical computations, and empirical analysis, to understand the logic, validity and robustness of various economic ideas.
- recognize that most branches of modern economics use mathematics and statistics extensively, and that some important areas of mathematical research have been motivated by economic problems.
- understand the complementarities between the two disciplines to gain proficiency in each, and appreciate the ways in which they are related.

## CONCENTRATION REQUIREMENTS

Students enrolling in the Area of Concentration in Mathematical Economics must major in either mathematics or economics.

### For students majoring in mathematics, the Concentration requires six courses:

- ECON 204 (Economic Statistics with Calculus) or MATH 203 (Statistical Methods and Their Applications), or any applied statistics course at a higher level offered by the economics or mathematics department.
- ECON 300 (Intermediate Microeconomics)
- Two electives in economics from the list of approved courses below.
- Two electives in mathematics from the list of approved courses below. (These courses may also be used to fulfill the requirements of the mathematics major.)

### For students majoring in economics, the Concentration requires six courses:

- Three required mathematics courses:
  - MATH 121 (Multivariable Calculus) or MATH 216 (Advanced Calculus)
  - MATH 215 (Linear Algebra)
  - MATH 317 (Analysis I)
- One elective in mathematics from the list of approved courses below.
- Two electives in economics from the list of approved courses below. (These courses may also be used to fulfill the requirements of the economics major.)

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### Additional Remarks

The Area of Concentration in Mathematical Economics differs from the minors in mathematics and economics in a specific way: it focuses on the complementarities between the two disciplines; the minors in mathematics and economics are designed to provide a basic foundation in each discipline, but not necessarily an inter-disciplinary orientation.

A student majoring in economics may choose to pursue either the Area of Concentration in Mathematical Economics or a minor in mathematics, but not both. A student majoring in mathematics may choose to pursue either the Area of Concentration in Mathematical Economics or a minor in economics, but not both. A student double-majoring in economics and mathematics may not enroll in the Area of Concentration in Mathematical Economics.

- ECON 360 Mathematical Economics; crosslisted as MATH 360
- ECON 374 Junior Research Seminar: Topics in Industrial Organization
- ECON 377 Junior Research Seminar: Political Economy

## FACULTY/COORDINATORS

### Giri Parameswaran

Assistant Professor of Economics, Economics Department Representative and Concentration Coordinator

### Robert Manning

Professor of Mathematics and Statistics, Mathematics Department Representative

## APPROVED ELECTIVES

The courses listed below can be used to fulfill the mathematics and economics elective requirements. Not all of the courses listed below are offered every year. In some years, courses are offered that are not on these lists but that can be used as electives in the concentration. Students wishing to receive credit for an elective not listed below must obtain approval from the concentration coordinator.

### Mathematics Electives

- MATH 210 Linear Optimization and Game Theory; crosslisted as ECON 210
- MATH 204 Differential Equations
- MATH 218 Probability
- MATH 222 Scientific Computing
- MATH 318 Analysis II
- MATH 328 Mathematical Statistics
- MATH 340 Analysis of Algorithms
- MATH 360 Mathematical Economics; crosslisted as ECON 360
- MATH 396 Advanced Topics in Probability and Statistics.
- MATH 397 Advanced Topics in Applied Mathematics

### Economics Electives

- ECON 210 Linear Optimization and Game Theory; crosslisted as MATH 210
- ECON 237 Game Theory in Economics
- ECON 355 Advanced Microeconomics: Uncertainty