MATHEMATICAL ECONOMICS

Faculty

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Mathematics has traditionally served as the language of the natural sciences, and more recently it has become a useful tool in the social sciences, particularly in economics.

The Bachelor of Science in Mathematical Economics at Bucknell University was developed jointly by the Department of Mathematics and the Department of Economics. It is a coordinated curriculum that incorporates economics, mathematics and statistics to provide the strong foundations that offer students both the intellectual and the quantitative skills to grapple with questions at the interface of these two disciplines.

Students interested in economics and mathematics could also consider a double major in economics and mathematics within the B.A. degree program, or combine a B.A. in one of these disciplines with an academic minor in the other. Students who plan to attend graduate school in economics might consider the mathematical economics major focusing on the theoretical track and add MATH 304 Statistical Inference Theory. Students undecided among these options are encouraged to contact a member of the coordinating committee.

Mathematical Economics Major

The B.S. **major** in mathematical economics requires a total of 18 credits: seven from economics, 10 from mathematics and one culminating experience.

The College of Arts & Sciences Core Curriculum (CASCC) culminating experience requirement and one W2 requirement will be satisfied with ECON 441 Econometric Research for the Statistical and Theoretical track, and with MATH 342 Topics in Finance or Industry for the Computational track.

Required Economics Courses

ECON 101	Economic Principles/Problems	1
ECON 202	Intermediate Microeconomics [1]	1
ECON 203	Intermediate Macroeconomics [1]	1
ECON 204	Intermediate Political Economy	1
ECON 241		1
Two economics courses [2]		2
Total Credits		**7**

1 ECON 202 Intermediate Microeconomics and ECON 203 Intermediate Macroeconomics address the information literacy goals of the CASCC.

2 Selected in consultation with the student's academic adviser. One must be at the 300 level.

Students preparing for graduate studies in economics are strongly encouraged to complete a one-credit senior thesis in economics.

Required Mathematics Courses

MATH 201	Calculus I	1
MATH 202	Calculus II	1
MATH 211	Calculus III	1
MATH 216	Statistics I [3]	1
MATH 217	Statistics II	1
MATH 245	Linear Algebra	1
MATH 303	Probability	1
Select one of the following tracks: [4]		3
Theoretical track		
MATH 280	Logic, Sets, and Proofs	
MATH 308	Real Analysis I	
MATH 345	Advanced Linear Algebra	
Computational track		
CSCI 203	Introduction to Computer Science	
MATH 343	Numerical Analysis	

MATH 358	Topics in Operations Research	
Statistical track		
MATH 304	Statistical Inference Theory	
MATH 358	Topics in Operations Research	
MATH 405	Statistical Modeling	
Total Credits		**10**

[3] MATH 216 Statistics I addresses the writing goal and the formal presentation goal of the CASCC.

[4] The track is selected in consultation with the academic adviser.

The recommended sequence of courses for students is as follows:

First Year

First Semester	Credits	Second Semester	Credits
ECON 101	1	ECON 202	1
MATH 201	1	MATH 202	1
		MATH 216	1
	2		**3**

Sophomore

First Semester	Credits	Second Semester	Credits
ECON 203	1	ECON 204	1
MATH 211	1	MATH 245	1
MATH 217	1	MATH 303	1
	3		**3**

Junior

First Semester	Credits	Second Semester	Credits
ECON 241	1	Economics elective	1
Mathematics track course 1	1	Mathematics track course 2	1
	2		**2**

Senior

First Semester	Credits	Second Semester	Credits
Second economics elective[5]	1	Culminating Experience[6]	1
Mathematics track course 3[5]	1	ECON 441 (Statistical or Theoretical track)	
		MATH 342 (Computational track)	
	2		**1**

Total Credits: 18

[5] Either first semester or second semester.

[6] ECON 441 and MATH 342 are offered during alternating spring semesters. The culminating experience course will be taken during the spring semester of junior or senior year, depending upon track.

Please see the Economics section and the Mathematics section of this catalog for a list of courses with course descriptions.

The goal of bachelor of science majors in mathematical economics is to combine the quantitative methods and the theoretical foundations of mathematics with the study of economics to address economic problems. The program learning goals are:

1. Demonstrate an understanding of the mathematical tools used in basic and advanced economic modeling.
2. Apply quantitative models and theoretical foundations of mathematics to the study of economic problems.
3. Apply regression and/or applied mathematical models to assess econometric theoretical hypotheses in varied and complex applications.

Economics Courses

ECON 101. Economic Principles/Problems. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
General introduction to both macroeconomics and microeconomics, along with an introduction to economic history, international economics, and political economy. The course also examines the origin of economic ideas in the works of Adam Smith, John Maynard Keynes, Karl Marx, and others.

ECON 104. The Evolution of Economic Ideas and Systems. .25 Credits.
Offered Fall, Spring, Summer; Lecture hours:1
This course covers how economic ideas evolved alongside changes in economic systems. Topics include the economic thought of Smith, Marx, Veblen, Keynes and Hayek, and economic systems such as ancient communism, empires, feudalism, mercantilism and various forms of capitalism. Students read and write independently on the topic.

ECON 127. International Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
An examination of international economic relations today and of the theory used to analyze trade and financial relations. Attention is given to the problems of government policy with respect to international issues.

ECON 198. Independent Study. .25-1 Credits.
Offered Fall, Spring or Summer; Lecture hours:Varies,Other:3; Repeatable
Independent Study - Individual product or project supervised by a member of the economics department.

ECON 202. Intermediate Microeconomics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Intermediate Microeconomic theory of the consumer, the firm, market structures, and resource allocation. Topics are introduced using differential calculus. Prerequisites: ECON 101 and (MATH 192 or MATH 201).

ECON 203. Intermediate Macroeconomics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The study of national income, employment, inflation, interest rates, and the impact of monetary and fiscal policy on the economy. Prerequisite: ECON 101 and (MATH 192 or MATH 201).

ECON 204. Intermediate Political Economy. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Intermediate study of Marxist and institutionalist political economy. The ideas of Marx and Veblen applied to such matters as the distribution of income and power, the environment, working conditions, consumerism, and race and gender issues. Prerequisite: ECON 101.

ECON 209. Economic Geography. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Inquiry into local and global changes in economic activity, location and spatial organization, especially focusing on implications for the well-being of people in particular places. Crosslisted as GEOG 209.

ECON 210. Introduction to Behavioral Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course introduces students to the field of economics focused on incorporating psychological insights into models of decision making and group interaction. This course provides students with an overview of an assortment of research topics and methods within the field of behavioral economics. Seniors require permission of the instructor.

ECON 215. Economics of Education. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course integrates the study of economics with education by employing economic principles, frameworks and analytical tools, to analyze and assess the various factors influencing educational decision-making, policies, resource allocation and outcomes. At its core, this course explores the fundamental question: What role does education play within the economy?.

ECON 217. Geographies of Uneven Development. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
In this course, we will build a critical understanding of the nature and processes of development in the global south countries while exploring the role of colonialism, imperialism and capitalism. Includes topics such as global political-economic change, population growth, human capital, microfinance, food politics and gender inequality. Crosslisted as GEOG 227.

ECON 220. Political Economy of Neoliberalism. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course interrogates our current economic period: Neoliberalism. We analyze power differentials and economic disparities created by neoliberalism. Specific attention is paid to the shifting role of government in the economy, mass incarceration, and the 2008 financial crisis. Prerequisite: ECON 101. First- and second-year students only; others by permission.

ECON 222. Economic Topics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
Selected issues in economic theory or policy. Prerequisite: ECON 101.

ECON 224. African Women & Social Action. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Analysis of topics in films and novels by Ousmane Sembene: pre-colonial history, colonialism, post-colonial independence, racial and gender oppression, worker exploitation, religious conflict, and modernization. Prerequisites: ECON 101 or permission of the instructor. Crosslisted as WMST 224.

ECON 226. Political Economy of the European Integration. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Introduction to core issues and theories related to the economic and political processes of European integration. Offered through Bucknell in London. Crosslisted as POLS 221.

ECON 231. Economics of Climate Change. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course reviews climate science and the sources and expected impacts of climate change. Domestic and international climate policy instruments are evaluated with special attention given to the effects of climate policy on economic development and equity. Prerequisite: ECON 101.

ECON 235. African Economic Development. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
A historical, institutional analysis of Sub-Saharan African economic, social, and political development. Primary emphasis will be on the analysis of the economic crisis facing the subcontinent since the late '70s and the structural adjustment programs that have been instituted to deal with the crisis. Prerequisite: ECON 101.

ECON 237. Health Politics and Health Policy. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
History of health care delivery and financing in the United States and introduction to and evaluation of current topics in health policy. Prerequisite: ECON 101 or permission of the instructor. First- or second-year standing, others by permission.

ECON 241. Econometrics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The application of statistical methods to quantify and test economic theories, analyze government policies, and forecast economic variables. Prerequisites: ECON 101 and (MATH 216 or MATH 227 or PSYC 215) and (MATH 192 or MATH 201).

ECON 243. Global Communities. 1 Credit.
Offered Occasionally; Lecture hours:3
This course explores the complexities of globalization, analyzing its benefits, challenges and diverse impacts. The course hones critical thinking, reading, writing and communication skills while addressing global political, economic, cultural and environmental issues. Students will engage with multiple perspectives to become informed participants in global discussions and problem-solving. Crosslisted as SOCI 343.

ECON 246. American Capitalism. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course explores the origins and development of capitalism in the United States. Property rights, how notions of time and space changed markets, prolitarianization, alienation, commodification, and the role the government played (or not) in shaping the economy are some of the topics that we will cover. Crosslisted as HIST 226.

ECON 260. Understanding Capitalism. 1 Credit.
Offered Occasionally; Lecture hours:3
The course exposes students to an analysis of how capitalism works via the work of two of its greatest analysts: Karl Marx and John Maynard Keynes. It analyzes the production, distribution, exchange and consumption of material wealth under the laws of capitalism.

ECON 270. South Africa: Social Entrepreneurship. 1 Credit.
Offered Summer Session Only; Lecture hours:15
The course examines the legacy of apartheid and the role of social entrepreneurship in transforming communities. Students are placed in community organizations in nearby townships. Prerequisite: permission of the instructor. Crosslisted as UNIV 284.

ECON 273. Latin American Economic Development. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The course deals with historic and contemporary economic problems, starting from colonial times and reaching the present integration into world economy. Crosslisted as IREL 278 and LAMS 273.

ECON 280. Political Economy of Media and Advertising. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Examines the interrelationship of cultural, political, and economic aspects of media content and advertising from the perspective of Institutional and Marxian political economy. Prerequisite: ECON 101 or permission of the instructor.

ECON 281. Understanding the Global Economy. 1 Credit.
Offered Either Fall or Spring; Lecture hours:1
This course develops a political economy framework to analyze the global economy. It covers theories of international trade, international finance, economic development, and technological change. The course applies the theoretical tools to assess how globalization influences performance, strategy, and policies within nations and firms, and across industries.

ECON 282. Introduction to Programming for Economics. 1 Credit.
Offered Occasionally; Lecture hours:3
Students are introduced to Python programming and some of its applications in economics and finance. Students develop the necessary skills to bring datasets to Python and answer interesting questions. The course covers the basics of preparing various data types, data visualization, and solving problems. No programming background is needed.

ECON 298. Independent Study. .25-1 Credits.
Offered Either Fall or Spring; Lecture hours:Varies,Other:3
Individual product or project supervised by a member of the economics department typically resulting in the production of a long research paper. Prerequisites: ECON 101 and permission of the instructor.

ECON 299. Teaching Assistants in Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course can only be taken by economic majors who have permission and have taken the prerequisites. Prerequisites: ECON 202 and ECON 203 and ECON 204 and permission of the instructor.

ECON 2NT. Economics Non-traditional Study. .25-1 Credits.
Offered Fall, Spring or Summer; Lecture hours:Varies,Other:Varies; Repeatable
Non-traditional study in economics. Prerequisite: permission of the department chair or the instructor.

ECON 304. Financial Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The course is focused on theory of finance and asset pricing. Topics include state pricing theory, capital asset pricing model, portfolio theory and risk aversion. Prerequisites: ECON 202 and (MATH 216 or MATH 227 or PSYC 215).

ECON 308. Economics of Innovation. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course introduces students to the important issues related to technological change and innovation – how new technologies impact the economy and our society. The lectures also focus on economic and social policies aimed at promoting growth and development.

ECON 311. Labor Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
An examination of economic models related to labor markets, current labor market trends, and the influence of related government policies. Prerequisites: ECON 202 and (MATH 216 or MATH 227 or MATH 304 or PSYC 215).

ECON 313. Public Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
An analysis of the government's role in the economy. Topics include the economic rationale for government, expenditure analysis, and the allocative and distributive consequences of taxation. It is strongly recommended that students have one semester of statistics. Prerequisite: ECON 202.

ECON 319. Economic History of Women in the United States. 1 Credit.
Offered Occasionally; Lecture hours:3
An examination of economic models related to labor markets, current labor market trends, and the influence of related government policies. Prerequisite: ECON 202 or ECON 203 or ECON 204. Crosslisted as WMST 318.

ECON 321. Social Theory: Deconstructing Power. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course will explore how we can understand power in the economy by studying different social theoretical approaches to power. Following a survey of theories of power, we will begin to apply these theories in economic contexts to understand how power hierarchies are created, sustained, maintained and changed.

ECON 326. History of Economic Thought. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Discussion of original sources of economic ideas. Readings about Quesnay, Smith, Ricardo, Marx, Marshall, Keynes, Hayek and others. Prerequisite: ECON 203 with a minimum grade of D and ECON 204 with a minimum grade of D.

ECON 328. Money and Financial Institutions. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
An analysis of the role of the financial system in the U.S. economy. Topics include determinants of asset prices, risk management, and financial regulations. Prerequisites: ECON 203 and (MATH 216 or MATH 227).

ECON 330. Law and Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course examines several areas of law from the "Law and Economics" perspective and analyzes the assumptions that underlie this approach to law. Property rights law, contract law, and tort law will be covered. Prerequisite: ECON 202.

ECON 333. Seminar in Economic Topics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
Guided discussion of economic issues. Topics to be announced at time of preregistration. Prerequisites: ECON 202 and ECON 203 and ECON 204 or permission of the instructor.

ECON 337. International Monetary and Financial Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The course covers balance of payments, foreign exchange markets, international monetary systems, the adjustment mechanism, macroeconomic policy in an open economy and monetary integration. Prerequisite: ECON 203 or permission of the instructor.

ECON 339. China & East Asian Economics. 1 Credit.
Lecture hours:3
An analysis of economic transition and development in China, with emphasis on its role in the Asia-Pacific and world economies. Prerequisites: ECON 202 and ECON 203 or permission of the instructor. Crosslisted as EAST 339.

ECON 342. Methods in Experimental Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course provides students with an introduction to methods used in conducting experimental economics research. The course explores different types of experiments (survey/lab/or field) used in economic research, experimental design and select research topics. Prerequisites: (ECON 202 or ECON 210) and (MATH 216 or MATH 227 or ANOP 102 or PSYC 215).

ECON 350. Classical Marxism. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
The goal is to develop an understanding of Marx's analysis of capitalism by reading mainly original texts by Marx and consider its applications both to disciplinary thinking and contemporary events. Crosslisted as GEOG 350.

ECON 353. Gender & Migration. 1 Credit.
Lecture hours:3
This course focuses on the role of gender in internal and international migrations. It covers gendered motivations for and patterns of migration; the global economy and migration, migration and families, forced migration, migration and economic restructuring, and transnational marriage and identity. Prerequisites ECON 203 or ECON 204 or WMST 150. Crosslisted as WMST 353.

ECON 357. Economic Development. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The main theories of development; economic and social dualism; agricultural, industrial, and trade strategies; and the role of less developed countries in the emerging global economy. Prerequisites: ECON 202 with a minimum grade of D and ECON 203 with a minimum grade of D and permission of the instructor.

ECON 358. Marxian Economics. 1 Credit.
Lecture hours:3
Applies Marxian value theory and class analysis to understand contemporary U.S. capitalism. Explains how prices are determined and how competition acts to distribute value, revolutionize technology and working conditions, and trigger economic crises. Explores gender and class in the enterprise and household and examines economic democracy as a viable alternative.

ECON 360. Political Economy of Advanced Capitalism: Economic Crises & Conflict. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course will focus on the structure and the dynamics of the advanced capitalist economies, including the United States. Among other topics, it will examine the empirical evidence and the theoretical claims of the political economy approach concerning economic and financial crises.

ECON 365. Global Value Chains: How the Modern World Economy Works. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The course provides an in-depth analysis of how our modern world capitalist economy organizes the politics and economics of contemporary supply chains by slicing up the financing, production, distribution, exchange, and consumption of the goods and services that we consume across the world.

ECON 398. Independent Study. .25-1 Credits.
Offered Either Fall or Spring; Lecture hours:Varies,Other:Varies; Repeatable
Individual study or project, supervised by instructor. Prerequisites: ECON 202 or ECON 203 or ECON 204 and permission of the instructor.

ECON 402. Economics of Inequality. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
A critical analysis of economic inequality focused on competing frameworks for inequality and proposed visions for what should be done. Topics include class conflict, race and ethnicity, gender, wealth, labor markets and social change. Prerequisites: ECON 202 and ECON 204.

ECON 405. Comparative Economic Systems. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
A comparison of the cultures and institutions of modern economic systems. The characteristics of selected capitalist, social democratic and socialist economies are assessed from mainstream, Institutionalist and Marxian analytical perspectives. Prerequisite: ECON 204 or permission of the instructor.

ECON 408. Seminar in Political Economy: The State and The Economy. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course analyzes the role of The State in the economy. We will explore alternative theoretical understandings of the role of the state. Following this, we will investigate the role the state is playing in the economy today. Is it the source of problems or the solution to current issues?.

ECON 410. Risk Management in Financial Markets. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
The course is focused on the applications of finance theory in asset pricing and risk management. The topical coverage will extend to fixed income, equity securities, options, derivatives, risk analysis, and hedging strategies. Prerequisite: ECON 202 or permission of the instructor.

ECON 412. Health Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Theoretical and empirical examinations of issues in health economics. Course includes semester-long research project on a health topic. Prerequisites: ECON 202 and (MATH 216 or MATH 227 or MATH 304).

ECON 418. American Economic History. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
An examination of the development and influence of American economic institutions from colonial to current times. Prerequisites: ECON 203 and ECON 204.

ECON 422. Experimental Economic Topics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Experimental economics uses researcher-controlled methods to investigate individual and group decision-making. In this course, students will critically analyze existing experimental economic research through discussion, reading and writing. Students will also learn best practices in experimental economic research through a semester-long research project.

ECON 426. Topics in the History of Economic Thought. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
Discussion of the relation between economic ideas and policy in the United States. Readings about Hamilton, Carey, Ely, Commons, Clark, Eccles, Okun, and others. Prerequisite: ECON 203.

ECON 427. International Economic Theory. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
Theoretical principles underlying international trade, investment, commercial policy, economic integration, adjustment mechanisms, and balance of payments policy will be examined with an application to current national/international policies. This course isn't open to students that have taken ECON 327. Prerequisites: ECON 203 and ECON 203.

ECON 429. Political Economy of Financial Crises. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
This course will explore the causes and consequences of financial crises from macroeconomic perspectives, with most of the attention given to the recent financial crisis in the United States. Prerequisite: ECON 204 or permission of the instructor.

ECON 441. Econometric Research. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Advanced panel data methods, instrumental variables and two stage least squares, simultaneous equations, limited dependent variables, sample selection bias, advanced time series, and writing and presenting an empirical research project. Prerequisites: (ECON 202 or ECON 203 or ECON 204) and (ECON 241 or ECON 341).

ECON 444. Senior Seminar in Economic Topics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Topics to be announced at the time of preregistration. Prerequisites: ECON 202 and ECON 203 and ECON 204.

ECON 450. Political Economy of Digital Capitalism. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
The course examines recent theoretical and empirical debates pertaining to the political economy of digital economic processes and their impact, in turn, on domestic and global development. Prerequisite: ECON 204 or permission of the instructor.

ECON 499. Honors Thesis in Economics. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3; Repeatable
Individual research, leading to an honors thesis in economics, undertaken by qualified students, and supervised by an instructor in the department of economics. Prerequisite: permission of instructor and Honors Council. Prerequisite: ECON 202 or ECON 203 or ECON 204.

Mathematics Courses

MATH 112. Introduction to Mathematical Modeling. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Introduction for the non-specialist to mathematical modeling of real-world phenomena such as voting and networks, using graph theory, probability, and other accessible tools.

MATH 150. Calculus Preparation. .5 Credits.
Offered Fall Semester Only; Lecture hours:3
Exploration of algebraic, exponential, logarithmic and trigonometric functions. Review and use of tools from differential calculus, including limits, to better understand those function classes. Emphasis on modeling and problem-solving techniques. Prerequisite: permission of the instructor.

MATH 192. Topics in Calculus. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:3
Elementary calculus and applications taken primarily from economics. Topics include algebraic, exponential, and logarithmic functions, graphs, limits, regular and partial derivatives, constrained optimization, and integration. Not open to students who have MATH 201 credit.

MATH 201. Calculus I. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:4
An introduction to the calculus of algebraic, trigonometric and transcendental functions. Interpretation, significance and calculations of derivatives. Applications to geometry, biology, physics, economics, and other subjects. Introduction to the integral, including the Fundamental Theorem of Calculus and substitution. Not open to students who have MATH 192 credit.

MATH 202. Calculus II. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:4
Methods of integration including integration by parts, numerical approximations, and improper integrals. Sequences and series, including Taylor series. Polar coordinates, parametric functions, differential equations, and applications. Prerequisite: MATH 201.

MATH 203. Introduction to Mathematical Thought. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:1.5
An investigation of number, numeration, and operations from the perspective of elementary school teachers and pupils. Open only to B.S. in Education Early Childhood students. Required fieldwork.

MATH 204. Elementary Geometry and Statistics. 1 Credit.
Offered Spring Semester Only; Lecture hours:3,Other:1.5
Investigation of geometric, probabilistic, and statistical concepts related to elementary mathematics and how children learn and make sense of these concepts. Required fieldwork. Prerequisites: MATH 203 or permission of the instructor.

MATH 207. The Teaching of Mathematics in Secondary Schools. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Other:1.5
Investigation into the components of effective secondary school mathematics instruction, including lesson design/ implementation (curriculum, tasks, discourse, and assessment). Required fieldwork. Prerequisite: EDUC 102 or EDUC 201 or permission of the instructor.

MATH 208. Mathematical Explorations. .5 Credits.
Offered Fall Semester Only; Lecture hours:3
An exploration of topics from pure mathematics, applied mathematics and statistics, illustrating the power and beauty of mathematical reasoning. For students considering a major in mathematics. Corequisites: MATH 201 or MATH 202 or MATH 211 or MATH 212 or MATH 216. Open to first-year students only.

MATH 211. Calculus III. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:4
Calculus of vector-valued functions and functions of several variables. Multiple, line, and surface integrals; applications, and extrema. Green's, Stokes' and Divergence Theorems. Prerequisite: MATH 202.

MATH 212. Differential Equations. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:3
Basic methods of solving ordinary differential equations. Systems of linear differential equations, Laplace transform, applications and selected topics. Prerequisite: MATH 211. Not open to students who have taken MATH 222.

MATH 216. Statistics I. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:3,Other:1
Exploratory data analysis, sampling and experimental designs, sampling distributions and confidence intervals, hypothesis testing, least squares regression and applications. Statistical software is used and a semester long project with real data is undertaken. Not open to students who have MATH 226, MATH 227, ENGR 226 or PSYC 215 credit.

MATH 217. Statistics II. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3,Other:1
Multiple linear regression, logistic regression and ANOVA. Inferential analysis emphasizing applications to a range of disciplines is conducted using statistical software. Prerequisite: MATH 216 or MATH 227 or equivalent. Students who have taken MATH 405 need instructor permission.

MATH 219. Topics in Applied Mathematics. 1 Credit.
Offered Occasionally; Lecture hours:3; Repeatable
Topics such as financial mathematics, mathematical biology, cryptography, social networks, etc. Topic varies by semester. Prerequisite: varies by topic.

MATH 222. Differential Equations for Engineers. .5 Credits.
TLC Tutoring Course,Offered Spring Semester Only; Lecture hours:3
First order differential equations, second order linear equations, higher order linear equations, numerical approximations. Prerequisite: MATH 211. Open only to civil engineering and environmental engineering students. Not open to students who have MATH 212 credit.

MATH 227. Statistics and Engineering. 1 Credit.
Offered Either Fall or Spring; Lecture hours:3
Probability theory, discrete and continuous random variables, sampling distributions and methods of statistical inference including regression and ANOVA. Software is used. Prerequisite: MATH 202. Open only to engineering students and students in computer science. Not open to students who have MATH 216 or ENGR 226 credit.

MATH 230. Data Visualization & Computing. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Simulation-based learning for concepts including sampling, sampling distributions, p-values, and confidence levels. Data visualization beyond simple exploratory data analysis techniques. Advanced statistical software will be used. Prerequisite: MATH 216 or MATH 227 or permission of the instructor.

MATH 240. Applied Combinatorics. .5 Credits.
Offered Spring Semester Only; Lecture hours:3
Counting techniques and traversal problems. Students join MATH 241 mid-semester. Pre- or co-requisite: MATH 280. Only for computer science students or students seeking secondary certification. Not open to students who have taken MATH 340.

MATH 241. Discrete Structures. 1 Credit.
TLC Tutoring Course,Offered Spring Semester Only; Lecture hours:3
Logic, sets; mathematical induction; relations, functions; combinatorics and graph theory. Not open to students with MATH 240 or MATH 280 credit. Prerequisite: MATH 202.

MATH 245. Linear Algebra. 1 Credit.
Offered Both Fall and Spring,TLC Tutoring Course; Lecture hours:3
Linear equations, matrices, vector spaces, linear transformations, eigenvalues, inner products, Gram-Schmidt algorithm, singular value decomposition. Prerequisite: MATH 202.

MATH 280. Logic, Sets, and Proofs. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Logic, sets; proof techniques; relations, functions, sequences and convergence; cardinality. Skills and tools for independent reading, problem solving and exploration. Not open to students with MATH 241 credit. Prerequisite: MATH 211 or MATH 245.

MATH 291. Undergraduate Readings. .25-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Readings and research in special topics at an intermediate level. Prerequisites: permission of the instructor, adviser, and department chair.

MATH 303. Probability. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Elementary probability, random variables, moments, central limit theorem, conditional expectation, statistical distributions derived from the normal distribution. History of the development of Probability. Probability simulations and applications from various fields. Prerequisite: MATH 211.

MATH 304. Statistical Inference Theory. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Point and interval estimation, Fisher's likelihood theory, hypothesis testing, simulation techniques. R or SAS will be used. Prerequisites: MATH 216 or MATH 227 and MATH 303, or permission of the instructor.

MATH 306. Statistical & Data Science Consulting. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
Experiential learning course where students work on collaborative data focused projects. Students will communicate findings to stakeholders and engage with important topics related to the art and practice of statistical consulting. Advanced statistical software will be used. Prerequisites: MATH 217 and MATH 230, or permission of the instructor.

MATH 308. Real Analysis I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Real numbers and elementary topology of Cartesian spaces, convergence, continuity, and differentiation. Prerequisites: MATH 211, MATH 245, and MATH 280.

MATH 311. Theory of Numbers. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Classical number theory in an algebraic setting. Topics include unique factorization, diophantine equations, and linear and quadratic congruences. Advanced topics from algebraic or analytic number theory. Prerequisites: MATH 245 and either MATH 241 or MATH 280 or permission of the instructor.

MATH 319. Topics in Advanced Mathematics. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3; Repeatable
Special topics, to be selected from algebra, analysis, geometry, statistics, applied mathematics, etc. Prerequisite varies by topic.

MATH 320. Abstract Algebra I. 1 Credit.
Offered Both Fall and Spring; Lecture hours:3
Groups and rings; homomorphisms, isomorphism theorems; history of the development of algebra. Additional selected topics. Prerequisites: MATH 245 and MATH 280.

MATH 333. Topology. 1 Credit.
Offered Alternating Fall Semester; Lecture hours:3
Topological spaces, connectedness, compactness, continuity, separation, and countability axioms. Metric, product, function, and uniform spaces. Prerequisites: MATH 211 and MATH 280, or permission of the instructor.

MATH 335. Geometry. 1 Credit.
Offered Alternating Fall Semester; Lecture hours:3
Historical and axiomatic foundations of geometry. Euclidean and non-Euclidean geometries. Prerequisite: MATH 280 or permission of the instructor.

MATH 340. Combinatorics & Graph Theory. 1 Credit.
Offered Alternating Spring Semester; Lecture hours:3
An introduction to combinatorics and graph theory. Topics include counting techniques, permutations, binomial coefficients, partitions, generating functions, graph traversal, spanning trees, matching theory, planar graphs; additional selected topics. Prerequisite: MATH 280 or permission of the instructor.

MATH 342. Topics in Finance or Industry. 1 Credit.
Offered Alternating Spring Semester; Lecture hours:3
Possible topics include industrial mathematics, financial mathematics, genetic algorithms, simulations, and network analysis. Will also include applications to economics and the writing and presenting of a project. Prerequisites: CSCI 203, MATH 245, and MATH 303 or permission of the instructor.

MATH 343. Numerical Analysis. 1 Credit.
Offered Fall Semester Only; Lecture hours:3,Lab:2
Floating point arithmetic, development of computational algorithms and error estimates for root approximation, interpolation and approximation by polynomials, numerical differentiation and integration, cubic splines, least-squares, linear systems. Lab component. Prerequisites: Two of (MATH 211, MATH 241, MATH 245, MATH 280) and (CSCI 203 or CSCI 204). Crosslisted as MATH 643.

MATH 345. Advanced Linear Algebra. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Rigorous treatment of linear algebra, including vector spaces, linear independence, span, basis, linear maps, matrices, eigenvalues, eigenvectors, inner products, the spectral theorem (complex and real). Additional topics may include: singular value decomposition, Jordan canonical form, various applications. Prerequisites: MATH 245 and either MATH 280 or permission of the instructor.

MATH 350. Partial Differential Equations. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Partial Differential Equations (PDEs) including the heat equation, wave equation, and Laplace's equation; existence and uniqueness of solutions to PDEs via the maximum principle and energy methods; method of characteristics; Fourier series and integral transforms; separation of variables; Sturm-Liouville theory and orthogonal expansions. Prerequisites: junior or senior status; MATH 212.

MATH 354. Modern Data Analysis. 1 Credit.
Offered Alternating Fall Semester; Lecture hours:3
Advanced methods in modern data analysis. Topics may include principal component analysis, random forest, clustering and classification, unsupervised learning, splines, longitudinal data analysis, survival analysis, time series, spatial statistics, and nonparametric methods. Prerequisite: MATH 230 and MATH 245, or permission of the instructor.

MATH 358. Topics in Operations Research. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Mathematical techniques in operations research. Stochastic processes and mathematical optimization. Topics may include Markov chains, queueing theory, simulation, linear programming, non-linear programming, integer programming, network optimization. Methods and applications drawn from various fields. Prerequisite: MATH 227 or MATH 303 or permission of the instructor. Crosslisted as MATH 658.

MATH 362. Complex Analysis. 1 Credit.
Offered Alternating Spring Semester; Lecture hours:3
Limits, analytic functions, integrals including contour integrals. Cauchy's Integral Theorem, entire functions and singularities. Prerequisites: MATH 211 and MATH 280, or permission of the instructor.

MATH 378. Seminar. .5 Credits.
Offered Either Fall or Spring; Lecture hours:2; Repeatable
Seminar based on topics from algebra, analysis, topology, differential equations, statistics, or applied mathematics; topics selected according to demand or interest. Prerequisite: permission of the instructor.

MATH 391. Reading and Research. .5-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Reading and research in various topics for qualified undergraduate students. Prerequisite: permission of the instructor.

MATH 405. Statistical Modeling. 1 Credit.
Offered Fall Semester Only; Lecture hours:3
Theory behind General Linear Models including multiple linear regression and logistic regression. Model diagnostics and remediation. Model selection, multicollinearity. R or SAS will be used. Prerequisites: MATH 245 and MATH 304.

MATH 407. Experimental Design. 1 Credit.
Offered Spring Semester Only; Lecture hours:3
Basic and advanced experimental designs (completely randomized, block, crossed, nested and mixed designs, fractional factorial, incomplete block, etc). Corresponding theory and application of estimation procedures including both frequentist and Bayesian estimation techniques. Advanced statistical software will be used. Prerequisite: MATH 304.

MATH 409. Real Analysis II. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Continuation of MATH 308. Integration theory and advanced topics in analysis. Prerequisite: MATH 308.

MATH 416. Advanced Methods in Mathematical Modeling. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
A survey of mathematical models grounded in differential equations and methods used to analyze the behavior of their solutions. Topics may include dynamical systems, asymptotics, perturbation methods, variational methods, numerical methods and scientific computing. Prerequisites: MATH 212 and MATH 308 or permission of the instructor. Crosslisted as MATH 616.

MATH 446. Abstract Algebra II. 1 Credit.
Offered Alternate Fall or Spring; Lecture hours:3
Continuation of MATH 320. Advanced topics in group theory including solvable groups, field theory and Galois theory. Prerequisite: MATH 320.

MATH 491. Reading and Research. .5-2 Credits.
Offered Either Fall or Spring; Lecture hours:Varies; Repeatable
Reading and research in various topics for qualified undergraduates or graduate students at a level appropriate for a Culminating Experience. Prerequisite: permission of the instructor, adviser, and department chair.