APPLIED MATHEMATICS AND STATISTICS, BACHELOR OF ARTS

Departmental majors can earn either the B.A. or the B.S. degree by meeting the general university requirements and the general requirements of the School of Engineering (see Requirements for a Bachelor’s Degree, including Writing Requirement, in this catalogue), and the departmental requirements.

Honors
The Department of Applied Mathematics and Statistics awards departmental honors based on a number of factors, including performance in coursework and research experience. To be eligible for departmental honors a student must:

1. achieve a 3.75 GPA in AMS Department courses (EN.553) used toward major requirements 1-11; and
2. earn a C- or better in an additional one semester course in AMS (EN.553) at the 300-level or higher, or undertake significant research activity (equivalent to a 3-credit course) in a subject related to applied mathematics. Such research can be conducted as an official research course, or the student may request that the research supervisor provide an assessment to AMS academic staff toward the middle of the semester of intended degree conferral.

Program Requirements
All courses used to meet the following departmental requirements must be taken for a letter grade and passed with grade of C- or higher:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1. Calculus I, II, and III</td>
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<tr>
<td>AS.110.108</td>
<td>Calculus I (Physical Sciences &amp; Engineering)</td>
<td>4</td>
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<tr>
<td>AS.110.109</td>
<td>Calculus II (For Physical Sciences and Engineering)</td>
<td>4</td>
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<tr>
<td>or AS.110.113</td>
<td>Honors Single Variable Calculus</td>
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<tr>
<td>AS.110.202</td>
<td>Calculus III</td>
<td>4</td>
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<tr>
<td>or AS.110.211</td>
<td>Honors Multivariable Calculus</td>
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<tr>
<td>2. Linear Algebra</td>
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<tr>
<td>AS.110.201</td>
<td>Linear Algebra</td>
<td>4</td>
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<tr>
<td>or AS.110.212</td>
<td>Honors Linear Algebra</td>
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<tr>
<td>or EN.553.291</td>
<td>Linear Algebra and Differential Equations</td>
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<tr>
<td>3. Differential Equations</td>
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<tr>
<td>AS.110.302</td>
<td>Differential Equations and Applications</td>
<td>3-4</td>
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<tr>
<td>or EN.553.391</td>
<td>Dynamical Systems</td>
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<tr>
<td>or EN.540.468</td>
<td>Introduction to Nonlinear Dynamics and Chaos</td>
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<td>4. Computer Languages and Programming</td>
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<tr>
<td>Select one of the following:</td>
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<tr>
<td>EN.500.112</td>
<td>Gateway Computing: JAVA</td>
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<tr>
<td>EN.500.113</td>
<td>Gateway Computing: Python</td>
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<tr>
<td>EN.500.114</td>
<td>Gateway Computing: Matlab</td>
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<tr>
<td>EN.553.281</td>
<td>Introduction to Mathematical Computing</td>
<td></td>
</tr>
</tbody>
</table>

EN.580.242 Biological Models and Simulations & EN.580.244 and Nonlinear Dynamics of Biological Systems
EN.601.220 Intermediate Programming
AS.250.205 Introduction to Computing

5. Numerical Linear Algebra
EN.553.385 Numerical Linear Algebra

6. Discrete Mathematics
Select one of the following:
EN.553.171 Discrete Mathematics
EN.553.172 Honors Discrete Mathematics
EN.553.371 Cryptology and Coding
EN.553.471 Combinatorial Analysis
EN.553.472 Graph Theory

7. Probability and Statistics
EN.553.420 Introduction to Probability
EN.553.430 Introduction to Statistics or EN.553.431 Honors Introduction to Statistics

8. Optimization
EN.553.361 Introduction to Optimization

9. Area of Focus
Select two courses from one of the following areas of focus. They must be distinct from those courses used to satisfy requirements 1-8.

Probability and Stochastic Processes
AS.110.405 Real Analysis I
AS.110.445 Mathematical and Computational Foundations of Data Science
EN.553.426 Introduction to Stochastic Processes
EN.553.427 Stochastic Processes and Applications to Finance
EN.553.433 Monte Carlo Methods
EN.553.492 Mathematical Biology

Statistics and Statistical Learning
AS.110.445 Mathematical and Computational Foundations of Data Science
EN.553.400 Mathematical Modeling and Consulting
EN.553.413 Applied Statistics and Data Analysis
EN.553.414 Applied Statistics and Data Analysis II
EN.553.416
EN.553.417
EN.553.432 Bayesian Statistics
EN.553.433 Monte Carlo Methods
EN.553.436 Introduction to Data Science
EN.553.439 Time Series Analysis
EN.553.450 Computational Molecular Medicine

Optimization and Operations Research
EN.553.362 Introduction to Optimization II
EN.553.400 Mathematical Modeling and Consulting
EN.553.453 Mathematical Game Theory
EN.553.463 Network Models in Operations Research
EN.553.465 Introduction to Convexity
EN.553.467 Deep Learning in Discrete Optimization

Discrete Mathematics
AS.110.401 Introduction to Abstract Algebra
EN.553.371 Cryptology and Coding
EN.553.463 Network Models in Operations Research
EN.553.471 Combinatorial Analysis
EN.553.472 Graph Theory

Financial Mathematics
EN.553.427 Stochastic Processes and Applications to Finance
EN.553.428 Stochastic Processes and Applications to Finance II
EN.553.441 Equity Markets and Quantitative Trading
EN.553.442 Investment Science
EN.553.444 Introduction to Financial Derivatives
EN.553.445 Interest Rate and Credit Derivatives
EN.553.447 Quantitative Portfolio Theory and Performance Analysis
EN.553.448 Financial Engineering and Structured Products
EN.553.449 Advanced Equity Derivatives
EN.553.488 Computing for Applied Mathematics

Computational Mathematics
EN.553.481 Numerical Analysis

and, one of
AS.110.445 Mathematical and Computational Foundations of Data Science
EN.553.433 Monte Carlo Methods
EN.553.467 Deep Learning in Discrete Optimization
EN.553.493 Mathematical Image Analysis

10. Scientific Computing
Select one of the following:
AS.110.445 Mathematical and Computational Foundations of Data Science
EN.553.400 Mathematical Modeling and Consulting
EN.553.413 Applied Statistics and Data Analysis
EN.553.416
EN.553.417
EN.553.432 Bayesian Statistics
EN.553.433 Monte Carlo Methods
EN.553.436 Introduction to Data Science
EN.553.450 Computational Molecular Medicine
EN.553.463 Network Models in Operations Research
EN.553.467 Deep Learning in Discrete Optimization
EN.553.481 Numerical Analysis
EN.553.488 Computing for Applied Mathematics
EN.553.493 Mathematical Image Analysis
EN.553.494 Applied and Computational Multilinear Algebra
EN.601.433 Intro Algorithms
EN.601.475 Machine Learning
EN.601.482 Machine Learning: Deep Learning

11. Quantitative Studies
Courses coded Quantitative Studies totaling 40 credits of which at least 18 credits must be in courses numbered 300 or higher. (Courses used to meet the requirements above may be counted toward this total.)

A student who earns credit in EN.553.291 Linear Algebra and Differential Equations may not earn credit for AS.110.302 Differential Equations and Applications.

or JHU credit for AP Computer Science A.

Students are strongly encouraged to fulfill this element of the requirement by taking EN.500.113 Gateway Computing: Python, and to do this in their first semester at Johns Hopkins University.

The requirements above together constitute a minimal core program, allowing maximum flexibility in planning degree programs. Students often are able to complete a second major during a four-year program or to proceed to the department’s combined bachelor’s/master’s degree program.

It is highly recommended that students develop a coherent program of study (see below) or at least take additional departmental courses, in order to establish a broad foundation for a career as an applied mathematician. Of particular importance are additional courses in optimization (EN.553.362 Introduction to Optimization II), stochastic processes (EN.553.426 Introduction to Stochastic Processes), statistics (EN.553.413 Applied Statistics and Data Analysis), dynamical systems (EN.553.413 Dynamical Systems), mathematical modeling and consulting (EN.553.400 Mathematical Modeling and Consulting), scientific computing (EN.553.385 Scientific Computing: Linear Algebra, EN.553.386 Scientific Computing: Differential Equations), and investment science (EN.553.442 Investment Science).

Students planning to continue to graduate school in an applied mathematics program are encouraged to consider taking one or more graduate-level courses in probability (EN.553.720 Probability Theory I, EN.553.721 Probability Theory II), statistics (EN.553.730 Statistical Theory, EN.553.731 Statistical Theory II), optimization (EN.553.761 Nonlinear Optimization I, EN.553.762 Nonlinear Optimization II), combinatorics (EN.553.671 Combinatorial Analysis), graph theory (EN.553.672 Graph Theory), numerical analysis (EN.553.781 Matrix Analysis and Linear Algebra), or matrix analysis (EN.553.792 Matrix Analysis and Linear Algebra).