APPLIED AND COMPUTATIONAL MATHEMATICS, MASTER OF SCIENCE

TheApplied and Computational Mathematics program is devoted to the study and development of mathematical disciplines especially oriented to the complex problems of modern society. Our curriculum emphasizes several areas of applied mathematics which have been grouped into five focus areas: Applied Analysis, Information Technology and Computation, Operations Research, Probability and Statistics, and Simulation and Modeling.

A focus area is not required for this program. Students may choose to specialize in one of these areas, or tailor their courses to meet their individual needs.

Admission Requirements

Applicants (degree seeking and special student) must meet the general requirements for admission to graduate study, as outlined in the Admission Requirements (https://e-catalogue.jhu.edu/engineering/engineering-professionals/admission-requirements/) section. The applicant’s prior education must include the following prerequisites:

1. at least one mathematics course beyond multivariate calculus (such as advanced calculus, differential equations, or linear algebra); and
2. familiarity with at least one programming language (e.g., C, C++, FORTRAN, Java, Python, R, or MATLAB).

Applicants whose prior education does not include the prerequisites listed above may still be admitted under provisional status, followed by full admission once they have completed the missing prerequisites. Missing prerequisites may be completed with Johns Hopkins Engineering or, with approval, at another nationally accredited institution. In addition to these requirements, a detailed work résumé, statement of purpose, and transcripts from all college studies must be submitted. Admitted students typically have earned a grade point average of at least 3.0 on a 4.0 scale (B or above) in the latter half of their undergraduate studies. When reviewing an application, the candidate’s academic and professional background will be considered.

Program Requirements

Ten courses must be completed within five years. The curriculum consists of four core courses (including a two-semester 700-level course sequence) and six electives. The six electives must include at least four courses from the Applied and Computational Mathematics (ACM) program (625.xxx) with at least two of the four ACM elective courses at the 700-level. At least one of two 700-level electives must not be on the list of core sequence courses (625.717/625.718, 625.721/625.722, and 625.725/625.726).

Home-to-Hopkins

Home-to-Hopkins students are permitted to substitute Homewood Campus courses to help meet EP program course requirements. Students should work with their faculty advisor to develop a course plan that will satisfy the degree requirements.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.603</td>
<td>Statistical Methods and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.601</td>
<td>Real Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or EN.625.609</td>
<td>Matrix Theory</td>
<td></td>
</tr>
</tbody>
</table>

Select one of the following sequences

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.725 &amp; EN.625.726</td>
<td>Theory Of Statistics I and Theory of Statistics II</td>
<td>6</td>
</tr>
</tbody>
</table>

1 courses may be taken in either order

An independent study (EN.625.800 Independent Study), research project (EN.625.801 Applied and Computational Mathematics Master’s Research—EN.625.802 Applied and Computational Mathematics Master’s Research), or thesis (EN.625.803 Applied and Computational Mathematics Master’s Thesis—EN.625.804 Applied and Computational Mathematics Master’s Thesis) may be substituted for one or two of the 700-level courses outside of the 700-level core sequence. The course 625.800 Independent Study may not be used towards the ACM M.S. if a student also wishes to count 625.801–802 or 625.803–804 towards the M.S. degree. Overall, given the requirements above, at least four 700- or 800-level ACM courses (625.xxx) must be completed. A student who has taken at least one semester of graduate statistics (outside of Applied and Computational Mathematics) may substitute another 625.xxx course for EN.625.603 Statistical Methods and Data Analysis with approval of the student’s advisor. The prior statistics course must be calculus-based and must cover the same general topics as EN.625.603 Statistical Methods and Data Analysis. Focus areas are not required for this program. Only one C-range grade (C+, C, or C–) can count toward the master’s degree. Course selections at the 800-level or outside of these core and focus area course lists are subject to advisor approval.

Courses

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.108</td>
<td>Calculus I</td>
<td>0</td>
</tr>
<tr>
<td>EN.625.109</td>
<td>Calculus II</td>
<td>0</td>
</tr>
<tr>
<td>EN.625.201</td>
<td>General Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.240</td>
<td>Introduction to Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.250</td>
<td>Multivariable Calculus and Complex Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.251</td>
<td>Introduction to Ordinary and Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.252</td>
<td>Linear Algebra and Its Applications</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.260</td>
<td>Introduction to Signals and Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

Students may take selected courses above as desired (e.g., as a refresher) or as required via provisional admissions status. Applicants whose prior education does not include the prerequisites listed under Admission Requirements may still be admitted under provisional status, followed by full admission once they have completed the missing prerequisites. These 100- and 200-level courses are not for graduate credit, and do not count toward the degree or certificate requirements.
Note that 625.250 fulfills a requirement for multivariable calculus (calculus III).

**Courses by Focus Areas**

The focus areas offered represent related groups of courses that are relevant for students with interests in the selected areas. The focus areas are presented as an aid to students in planning their course schedules and are generally applicable to students seeking a master's degree; the more advanced courses within each focus area may also apply to the post-master's certificate. A Focus Area can be selected, but is not required for this program. They do not appear as official designations on a student's transcript or diploma.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN.625.601</td>
<td>Real Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.602</td>
<td>Modern Algebra</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.604</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.609</td>
<td>Matrix Theory</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.648</td>
<td>Computational Methods</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.680</td>
<td>Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.685</td>
<td>Number Theory</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.687</td>
<td>Applied Topology</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.690</td>
<td>Computational Complexity and Approximation</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.703</td>
<td>Complex Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.710</td>
<td>Fourier Analysis with Applications to Signal Processing and Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.717</td>
<td>Advanced Differential Equations: Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.718</td>
<td>Advanced Differential Equations: Nonlinear Differential Equations and Dynamical Systems</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.728</td>
<td>Theory of Probability</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.736</td>
<td>Combinatorial Optimization</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.800</td>
<td>Independent Study</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.801</td>
<td>Applied and Computational Mathematics Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.802</td>
<td>Applied and Computational Mathematics Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.803</td>
<td>Applied and Computational Mathematics Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.804</td>
<td>Applied and Computational Mathematics Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.805</td>
<td>Applied and Computational Mathematics Post-Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.806</td>
<td>Applied and Computational Mathematics Post-Master's Research</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.807 &amp; EN.625.808</td>
<td>Applied and Computational Mathematics Post-Master's Thesis</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Information Technology and Computation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
</tr>
<tr>
<td>EN.625.603</td>
</tr>
<tr>
<td>EN.625.609</td>
</tr>
<tr>
<td>EN.625.611</td>
</tr>
<tr>
<td>EN.625.615</td>
</tr>
<tr>
<td>EN.625.616</td>
</tr>
<tr>
<td>EN.625.617</td>
</tr>
<tr>
<td>EN.625.618</td>
</tr>
<tr>
<td>EN.625.623</td>
</tr>
<tr>
<td>EN.625.624</td>
</tr>
<tr>
<td>EN.625.633</td>
</tr>
<tr>
<td>EN.625.638</td>
</tr>
<tr>
<td>EN.625.661</td>
</tr>
<tr>
<td>EN.625.665</td>
</tr>
<tr>
<td>EN.625.680</td>
</tr>
<tr>
<td>EN.625.685</td>
</tr>
<tr>
<td>EN.625.687</td>
</tr>
<tr>
<td>EN.625.690</td>
</tr>
<tr>
<td>EN.625.695</td>
</tr>
<tr>
<td>EN.625.725</td>
</tr>
<tr>
<td>EN.625.726</td>
</tr>
<tr>
<td>EN.625.734</td>
</tr>
<tr>
<td>EN.625.740</td>
</tr>
<tr>
<td>EN.625.742</td>
</tr>
<tr>
<td>EN.625.743</td>
</tr>
<tr>
<td>EN.625.744</td>
</tr>
<tr>
<td>EN.625.800</td>
</tr>
<tr>
<td>EN.625.801 &amp; EN.625.802</td>
</tr>
<tr>
<td>EN.625.805 &amp; EN.625.806</td>
</tr>
<tr>
<td>EN.625.807 &amp; EN.625.808</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operations Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
</tr>
<tr>
<td>EN.625.603</td>
</tr>
<tr>
<td>EN.625.609</td>
</tr>
</tbody>
</table>


Probability and Statistics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.603</td>
<td>Statistical Methods and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.617</td>
<td>Intro to Enumerative Combinatorics</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.620</td>
<td>Mathematical Methods for Signal Processing</td>
<td>3</td>
</tr>
</tbody>
</table>

Simulation and Modeling

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.625.603</td>
<td>Statistical Methods and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.604</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.623</td>
<td>Introduction to Operations Research: Probability Models</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.633</td>
<td>Monte Carlo Methods</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.638</td>
<td>Neural Networks</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.641</td>
<td>Mathematics of Finance</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.642</td>
<td>Mathematics of Risk, Options, and Financial Derivatives</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.651</td>
<td>Mathematical Models in Healthcare</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.661</td>
<td>Statistical Models and Regression</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.662</td>
<td>Design and Analysis of Experiments</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.663</td>
<td>Multivariate Statistics and Stochastic Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.664</td>
<td>Computational Statistics</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.665</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.680</td>
<td>Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.690</td>
<td>Computational Complexity and Approximation</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.692</td>
<td>Probabilistic Graphical Models</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.695</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.710</td>
<td>Fourier Analysis with Applications to Signal Processing and Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.714</td>
<td>Introductory Stochastic Differential Equations with Applications</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.721</td>
<td>Probability and Stochastic Process I</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.722</td>
<td>Probability and Stochastic Process II</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.725</td>
<td>Theory Of Statistics I</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.726</td>
<td>Theory of Statistics II</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.734</td>
<td>Queuing Theory with Applications to Computer Science</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.736</td>
<td>Combinatorial Optimization</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.740</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.741</td>
<td>Game Theory</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.743</td>
<td>Stochastic Optimization &amp; Control</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.744</td>
<td>Modeling, Simulation, and Monte Carlo</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.800</td>
<td>Independent Study</td>
<td>3</td>
</tr>
<tr>
<td>EN.625.801</td>
<td>Applied and Computational Mathematics Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>&amp; EN.625.802</td>
<td>and Applied and Computational Mathematics Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.803</td>
<td>Applied and Computational Mathematics Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>&amp; EN.625.804</td>
<td>and Applied and Computational Mathematics Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.805</td>
<td>Applied and Computational Mathematics Post-Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>&amp; EN.625.806</td>
<td>and Applied and Computational Mathematics Post-Master's Research</td>
<td>6</td>
</tr>
<tr>
<td>EN.625.807</td>
<td>Applied and Computational Mathematics Post-Master's Thesis</td>
<td>6</td>
</tr>
<tr>
<td>&amp; EN.625.808</td>
<td>and Applied and Computational Mathematics Post-Master's Thesis</td>
<td>6</td>
</tr>
</tbody>
</table>
## Electives

Two electives may be from the Applied and Computational Mathematics (ACM) program or from another graduate program provided the courses have significant mathematical content. The following is a list of approved non-ACM electives. Electives from outside of this list must be approved by an advisor.

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>EN.525.605</td>
<td>Intermediate Electromagnetics</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.614</td>
<td>Probability &amp; Stochastic Processes for Engineers</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.616</td>
<td>Communication Systems Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.627</td>
<td>Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.645</td>
<td>Modern Navigation Systems</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.661</td>
<td>UAV Systems and Control</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.707</td>
<td>Error Control Coding</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.721</td>
<td>Advanced Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.724</td>
<td>Introduction to Pattern Recognition</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.762</td>
<td>Introduction to Wavelets</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.770</td>
<td>Intelligent Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.776</td>
<td>Information Theory</td>
<td>3</td>
</tr>
<tr>
<td>EN.525.780</td>
<td>Multidimensional Digital Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EN.535.621</td>
<td>Intermediate Fluid Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.627</td>
<td>Stochastic Processes and Applications to Finance</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.642</td>
<td>Investment Science</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.644</td>
<td>Introduction to Financial Derivatives</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.645</td>
<td>Interest Rate and Credit Derivatives</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.646</td>
<td>Financial Risk Management and Measurement</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.647</td>
<td>Quantitative Portfolio Theory &amp; Performance Analysis</td>
<td>3</td>
</tr>
<tr>
<td>EN.555.648</td>
<td>Financial Engineering and Structured Products</td>
<td>3</td>
</tr>
<tr>
<td>EN.575.608</td>
<td>Optimization Methods for Public Decision Making</td>
<td>3</td>
</tr>
<tr>
<td>EN.575.704</td>
<td>Applied Statistical Analysis and Design of Experiments for Environmental Applications</td>
<td>3</td>
</tr>
<tr>
<td>EN.585.719</td>
<td>Sparse Representations in Computer Vision and Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.621</td>
<td>Foundations of Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.622</td>
<td>Computational Signal Processing</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.633</td>
<td>Social Media Analytics</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.645</td>
<td>Artificial Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.646</td>
<td>Natural Language Processing</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.649</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.671</td>
<td>Principles of Data Communications Networks</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.716</td>
<td>Modeling and Simulation of Complex Systems</td>
<td>3</td>
</tr>
<tr>
<td>EN.605.729</td>
<td>Formal Methods</td>
<td>3</td>
</tr>
<tr>
<td>EN.615.641</td>
<td>Mathematical Methods for Physics and Engineering</td>
<td>3</td>
</tr>
<tr>
<td>EN.615.765</td>
<td>Chaos and Its Applications</td>
<td>3</td>
</tr>
<tr>
<td>EN.615.769</td>
<td>Physics of Remote Sensing</td>
<td>3</td>
</tr>
<tr>
<td>EN.615.775</td>
<td>Physics of Climate</td>
<td>3</td>
</tr>
<tr>
<td>EN.685.648</td>
<td>Data Science</td>
<td>3</td>
</tr>
<tr>
<td>EN.695.615</td>
<td>Cyber Physical Systems Security</td>
<td>3</td>
</tr>
<tr>
<td>EN.695.641</td>
<td>Cryptology</td>
<td>3</td>
</tr>
</tbody>
</table>
Please refer to the course schedule (ep.jhu.edu/schedule) published each term for exact dates, times, locations, fees, and instructors.