Mathematics and Statistics

Phone: 314-935-6301
Email: mathadvising@wustl.edu
Website: http://math.wustl.edu

Majors

Requirements for All Majors

Total units required: 12 units

- The three-course calculus sequence (9 units)* and an introductory computer science course (3 units)**:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 131</td>
<td>Calculus I</td>
<td>3</td>
</tr>
<tr>
<td>Math 132</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>Math 233</td>
<td>Calculus III</td>
<td>3</td>
</tr>
<tr>
<td>CSE 131</td>
<td>Introduction to Computer Science</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total Units</strong></td>
<td></td>
<td><strong>12</strong></td>
</tr>
</tbody>
</table>

* AP credit can be applied, and students who have completed Math 203 Honors Mathematics I and Math 204 Honors Mathematics II will have this requirement waived.

** This course may be waived after consultation with the director of undergraduate studies of the Department of Computer Science & Engineering.

The Major in Mathematical Sciences

Total units required: 24 units of upper-level courses, including the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 309</td>
<td>Matrix Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 310</td>
<td>Foundations for Higher Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 310W</td>
<td>Foundations for Higher Mathematics with Writing</td>
<td></td>
</tr>
<tr>
<td>Math 3200</td>
<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

- One of the following full-year 400-level sequences*:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 411</td>
<td>Introduction to Analysis</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 412</td>
<td>and Introduction to Lebesgue Integration</td>
<td></td>
</tr>
<tr>
<td>Math 417</td>
<td>Topology I</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 418</td>
<td>and Topology II</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 409</td>
<td>Linear Algebra</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 410</td>
<td>and Modern Algebra</td>
<td></td>
</tr>
<tr>
<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 450</td>
<td>and Topics in Applied Mathematics</td>
<td></td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>6</td>
</tr>
<tr>
<td>&amp; Math 498</td>
<td>and Linear Statistical Models</td>
<td></td>
</tr>
</tbody>
</table>

* Students whose primary major is secondary education may fulfill this requirement by taking Math 302 Elementary Geometry from an Advanced Point of View and Math 331 Algebraic Systems.

- At least one course from the following list (that has not already been used to fulfill any of the previous requirements listed):

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
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</thead>
<tbody>
<tr>
<td>Math 370</td>
<td>Introduction to Combinatorics</td>
<td>3</td>
</tr>
<tr>
<td>Math 371</td>
<td>Graph Theory</td>
<td>3</td>
</tr>
<tr>
<td>Math 410</td>
<td>Introduction to Fourier Series and Integrals</td>
<td></td>
</tr>
<tr>
<td>Math 411</td>
<td>Introduction to Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 415</td>
<td>Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>Math 416</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>Math 417</td>
<td>Topology I</td>
<td>3</td>
</tr>
<tr>
<td>Math 429</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 434</td>
<td>Survival Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 435</td>
<td>Number Theory and Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
<td>3</td>
</tr>
</tbody>
</table>

The Major in Mathematics

Total units required: 30 units of upper-level courses, including the following:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 310</td>
<td>Foundations for Higher Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 310W</td>
<td>Foundations for Higher Mathematics with Writing</td>
<td></td>
</tr>
<tr>
<td>Math 411</td>
<td>Introduction to Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 412</td>
<td>Introduction to Lebesgue Integration</td>
<td>3</td>
</tr>
<tr>
<td>Math 429</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 430</td>
<td>Modern Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 416</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>Math 417</td>
<td>Topology I</td>
<td>3</td>
</tr>
</tbody>
</table>

At least one of the following:
McKelvey Engineering students who declare this major must fulfill the core course requirements listed below and all other requirements for the Applied Science degree (http://bulletin.wustl.edu/undergrad/engineering/requirements/) in the McKelvey School of Engineering. They must also complete Engr 310 Technical Writing and 8 units of courses designated as NSM (Natural Sciences & Math) from Anthropology (L48 Anthro), Biology and Biomedical Sciences (L41 Biol), Chemistry (L07 Chem), Earth and Planetary Sciences (L19 EPSc), Physics (L31 Physics) or Environmental Studies (L82 EnSt).

Arts & Sciences students who declare this major must fulfill the distribution requirements and all other requirements for an AB degree (http://bulletin.wustl.edu/undergrad/artsci/requirements/) in addition to the specific requirements listed below.

### Core Course Requirements

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 131</td>
<td>Introduction to Computer Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 247</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>Math 131</td>
<td>Calculus I (AP credit may satisfy this requirement)</td>
<td>3</td>
</tr>
<tr>
<td>Math 132</td>
<td>Calculus II (AP credit may satisfy this requirement)</td>
<td>3</td>
</tr>
<tr>
<td>Math 233</td>
<td>Calculus III</td>
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</tr>
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<td>Foundations for Higher Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 310W</td>
<td>Foundations for Higher Mathematics with Writing</td>
<td>3</td>
</tr>
<tr>
<td>or CSE 240</td>
<td>Logic and Discrete Mathematics</td>
<td></td>
</tr>
<tr>
<td>Math 309</td>
<td>Matrix Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 3200</td>
<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 3200</td>
<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>3</td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 475</td>
<td>Statistical Computation</td>
<td></td>
</tr>
</tbody>
</table>

**Total Units** 27

### Electives

Eight upper-level courses from Math or Computer Science & Engineering can be chosen from the approved list, with the following caveats:

- At least three courses must be taken from CSE and at least three course must be taken from Math.
- Up to two preapproved courses from outside both departments can be selected.
- CSE 400 Independent Study or CSE 400E Independent Study may be taken for a maximum of 3 units and must be approved by a CS+Math review committee.

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The McKelvey School of Engineering and the College of Arts & Sciences developed a new major that efficiently captures the intersection of the complementary studies of computer science and math.

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The Major in Mathematics and Computer Science

The McKelvey Engineering students who declare this major must fulfill the core course requirements listed below and all other requirements for the Applied Science degree (http://bulletin.wustl.edu/undergrad/engineering/requirements/) in the McKelvey School of Engineering. They must also complete Engr 310 Technical Writing and 8 units of courses designated as NSM (Natural Sciences & Math) from Anthropology (L48 Anthro), Biology and Biomedical Sciences (L41 Biol), Chemistry (L07 Chem), Earth and Planetary Sciences (L19 EPSc), Physics (L31 Physics) or Environmental Studies (L82 EnSt).

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<td>3</td>
</tr>
<tr>
<td>or CSE 240</td>
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<td></td>
</tr>
<tr>
<td>Math 309</td>
<td>Matrix Algebra</td>
<td>3</td>
</tr>
<tr>
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<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 3200</td>
<td>Elementary to Intermediate Statistics and Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>3</td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 475</td>
<td>Statistical Computation</td>
<td></td>
</tr>
</tbody>
</table>

**Total Units** 27

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# List of Approved Electives

## Computer Science & Engineering

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 217A</td>
<td>Introduction to Data Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 341T</td>
<td>Parallel and Sequential Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 411A</td>
<td>AI and Society</td>
<td>3</td>
</tr>
<tr>
<td>CSE 412A</td>
<td>Introduction to Artificial Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>CSE 416A</td>
<td>Analysis of Network Data</td>
<td>3</td>
</tr>
<tr>
<td>CSE 417T</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CSE 427T</td>
<td>Cloud Computing with Big Data Applications</td>
<td>3</td>
</tr>
<tr>
<td>CSE 442T</td>
<td>Introduction to Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>CSE 447T</td>
<td>Introduction to Formal Languages and Automata</td>
<td>3</td>
</tr>
<tr>
<td>CSE 468T</td>
<td>Introduction to Quantum Computing</td>
<td>3</td>
</tr>
<tr>
<td>CSE 513T</td>
<td>Theory of Artificial Intelligence and Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CSE 514A</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>CSE 515T</td>
<td>Bayesian Methods in Machine Learning</td>
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</tr>
<tr>
<td>CSE 516A</td>
<td>Multi-Agent Systems</td>
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</tr>
<tr>
<td>CSE 517A</td>
<td>Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CSE 518A</td>
<td>Human-in-the-Loop Computation</td>
<td>3</td>
</tr>
<tr>
<td>CSE 533T</td>
<td>Coding and Information Theory for Data Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 534A</td>
<td>Large-Scale Optimization for Data Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 541T</td>
<td>Advanced Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 543T</td>
<td>Algorithms for Nonlinear Optimization</td>
<td>3</td>
</tr>
<tr>
<td>CSE 544T</td>
<td>Special Topics in Computer Science Theory</td>
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</tr>
<tr>
<td>CSE 546T</td>
<td>Computational Geometry</td>
<td>3</td>
</tr>
<tr>
<td>CSE 554A</td>
<td>Geometric Computing for Biomedicine</td>
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</tr>
<tr>
<td>CSE 555T</td>
<td>Adversarial AI</td>
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</tr>
<tr>
<td>CSE 559A</td>
<td>Computer Vision</td>
<td>3</td>
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<tr>
<td>CSE 581T</td>
<td>Approximation Algorithms</td>
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<tr>
<td>CSE 584A</td>
<td>Algorithms for Biosequence Comparison</td>
<td>3</td>
</tr>
<tr>
<td>CSE 587A</td>
<td>Algorithms for Computational Biology</td>
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</tbody>
</table>

## Mathematics and Statistics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 350</td>
<td>Dynamical Systems and Chaos</td>
<td>3</td>
</tr>
<tr>
<td>Math 370</td>
<td>Introduction to Combinatorics</td>
<td>3</td>
</tr>
<tr>
<td>Math 371</td>
<td>Graph Theory</td>
<td>3</td>
</tr>
<tr>
<td>Math 4111</td>
<td>Introduction to Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 4121</td>
<td>Introduction to Lebesgue Integration</td>
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</tr>
<tr>
<td>Math 4171</td>
<td>Topology I</td>
<td>3</td>
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<tr>
<td>Math 420</td>
<td>Experimental Design</td>
<td>3</td>
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<tr>
<td>Math 429</td>
<td>Linear Algebra</td>
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</tr>
<tr>
<td>Math 430</td>
<td>Modern Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 434</td>
<td>Survival Analysis</td>
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<tr>
<td>Math 4351</td>
<td>Number Theory and Cryptography</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
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<tr>
<td>Math 444</td>
<td>The Mathematics of Quantum Theory</td>
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<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
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<tr>
<td>Math 450</td>
<td>Topics in Applied Mathematics</td>
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<tr>
<td>Math 456</td>
<td>Topics in Financial Mathematics</td>
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<td>Math 459</td>
<td>Bayesian Statistics</td>
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<td>Math 460</td>
<td>Multivariate Statistical Analysis</td>
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<td>Math 4601</td>
<td>Statistical Learning</td>
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<tr>
<td>Math 461</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 462</td>
<td>Mathematical Foundations of Big Data</td>
<td>3</td>
</tr>
<tr>
<td>Math 470</td>
<td>Analytic Combinatorics</td>
<td>3</td>
</tr>
<tr>
<td>Math 475</td>
<td>Statistical Computation</td>
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</tr>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>3</td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 495</td>
<td>Stochastic Processes</td>
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## Electrical & Systems Engineering

<table>
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<th>Title</th>
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<tbody>
<tr>
<td>ESE 4031</td>
<td>Optimization for Engineered Planning, Decisions and Operations</td>
<td>3</td>
</tr>
<tr>
<td>ESE 415</td>
<td>Optimization</td>
<td>3</td>
</tr>
<tr>
<td>ESE 417</td>
<td>Introduction to Machine Learning and Pattern Classification</td>
<td>3</td>
</tr>
<tr>
<td>ESE 427</td>
<td>Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>ESE 429</td>
<td>Basic Principles of Quantum Optics and Quantum Information</td>
<td>3</td>
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<tr>
<td>ESE 520</td>
<td>Probability and Stochastic Processes</td>
<td>3</td>
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</table>

## Economics

<table>
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<tr>
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<tbody>
<tr>
<td>Econ 4151</td>
<td>Applied Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 467</td>
<td>Game Theory</td>
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## Biology and Biomedical Sciences

<table>
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<tr>
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<tbody>
<tr>
<td>Biol 5657</td>
<td>Biological Neural Computation</td>
<td>3</td>
</tr>
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</table>

## Biomedical Engineering

<table>
<thead>
<tr>
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<th>Units</th>
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<tbody>
<tr>
<td>BME 470</td>
<td>Mathematics of Imaging Science</td>
<td>3</td>
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The Major in Mathematics and Economics

Required courses:

<table>
<thead>
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<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econ 1011</td>
<td>Introduction to Microeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 1021</td>
<td>Introduction to Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 4011</td>
<td>Intermediate Microeconomic Theory</td>
<td>3</td>
</tr>
<tr>
<td>Econ 4021</td>
<td>Intermediate Macroeconomic Theory</td>
<td>3</td>
</tr>
<tr>
<td>Econ 413</td>
<td>Introduction to Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>or Econ 413W</td>
<td>Introduction to Econometrics with Writing</td>
<td></td>
</tr>
<tr>
<td>Math 131</td>
<td>Calculus I</td>
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<td>Math 3200</td>
<td>Elementary to Intermediate Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 493</td>
<td>and Data Analysis with Probability</td>
<td></td>
</tr>
<tr>
<td>Math 310</td>
<td>Foundations for Higher Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>or Math 310W</td>
<td>Foundations for Higher Mathematics with Writing</td>
<td></td>
</tr>
<tr>
<td>Total Units</td>
<td></td>
<td>33</td>
</tr>
</tbody>
</table>

Elective courses:

Majors must complete seven electives, with three in each discipline and one from either department.

In Economics:

One of the three electives can be any economics course with Econ 4011 or Econ 4021 as a prerequisite, including from an approved study abroad program. The other two economics electives must come from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econ 404</td>
<td>Behavioral Economics and Experimental Economics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 407</td>
<td>Market Design</td>
<td>3</td>
</tr>
<tr>
<td>Econ 410</td>
<td>Macroeconomics of Inequality</td>
<td>3</td>
</tr>
<tr>
<td>Econ 4151</td>
<td>Applied Econometrics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 429</td>
<td>Decision Under Risk and Time</td>
<td>3</td>
</tr>
<tr>
<td>Econ 435</td>
<td>Open Economy Macroeconomics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 437</td>
<td>The Economics of Financial Intermediation</td>
<td>3</td>
</tr>
<tr>
<td>Econ 452</td>
<td>Industrial Organization</td>
<td>3</td>
</tr>
<tr>
<td>Econ 460</td>
<td>Urban Economics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 467</td>
<td>Game Theory</td>
<td>3</td>
</tr>
<tr>
<td>Econ 471</td>
<td>Development Economics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 477</td>
<td>Topics in Financial Economics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 480</td>
<td>Labor Economics</td>
<td>3</td>
</tr>
<tr>
<td>Econ 484</td>
<td>Computational Macroeconomics</td>
<td>3</td>
</tr>
</tbody>
</table>

- With instructor permission, students may use any of the following for economics elective credit: Econ 501, Econ 502, Econ 503, Econ 504, Econ 511, or Econ 513.
- Econ 413 may be taken from an approved study abroad program. Consult with Academic Coordinator Dorothy Petersen in the Department of Economics for more information.

In Mathematics:

For Mathematics, the electives can come from the following list:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 410</td>
<td>Introduction to Fourier Series and Integrals</td>
<td>3</td>
</tr>
<tr>
<td>Math 415</td>
<td>Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>Math 416</td>
<td>Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>Math 4111</td>
<td>Introduction to Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 4121</td>
<td>Introduction to Lebesgue Integration</td>
<td>3</td>
</tr>
<tr>
<td>Math 429</td>
<td>Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 4392</td>
<td>Advanced Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 450</td>
<td>Topics in Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 456</td>
<td>Topics in Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 460</td>
<td>Multivariate Statistical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 461</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 462</td>
<td>Mathematical Foundations of Big Data</td>
<td>3</td>
</tr>
<tr>
<td>Math 475</td>
<td>Statistical Computation</td>
<td>3</td>
</tr>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>3</td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 495</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
</tbody>
</table>

Advising, Questions, and Further Considerations:

- Students may declare a prime or a second major in Math + Economics via L24 (Math) or L11 (Econ), and that will determine their major advisor.
- It is possible to earn the Certificate in Financial Economics in conjunction with this major (prime or second).
- It is possible to graduate with Latin Honors or with “English” honors. Students should refer to the departments’ websites or consult with either Professor Blake Thornton (bthornton@wustl.edu) in the Department of Mathematics and Statistics or Academic Coordinator Dorothy Petersen (dottie@wustl.edu) in the Department of Economics for more information.
Substitutions for mathematics courses and study abroad approval for mathematics courses will be determined by the Department of Mathematics and Statistics.

Substitutions for economics courses and study abroad approval will be determined by Academic Coordinator Dorothy Petersen in the Department of Economics.

Substitutions for CSE 131 are subject to approval by the McKelvey School of Engineering.

The Bachelor of Science in Data Science

The McKelvey School of Engineering and the College of Arts & Sciences developed a new major that efficiently captures the intersection of mathematics and statistics with computer science for data science. The Bachelor of Science in Data Science (BSDS) will give students the formal foundation needed to understand the applicability and consequences of the various approaches to analyzing data with a focus on statistical modeling and machine learning.

McKelvey Engineering students who declare this major must fulfill the core course requirements listed below and all other requirements for the Applied Science degree (http://bulletin.wustl.edu/undergrad/engineering/requirements/) in the McKelvey School of Engineering. They must also complete Engr 310 Technical Writing and 8 units of courses designated as NSM (Natural Sciences & Math) from Anthropology (L48 Anthro), Biology and Biomedical Sciences (L41 Biol), Chemistry (L07 Chem), Earth and Planetary Sciences (L19 EPSc), Physics (L31 Physics) or Environmental Studies (L82 EnSt).

Arts & Sciences students who declare this major must fulfill the distribution requirements and all other requirements for an AB degree (http://bulletin.wustl.edu/undergrad/artsci/requirements/) in addition to the specific requirements listed below.

Data Science Core Requirements (CR)

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 131</td>
<td>Calculus I</td>
<td>3</td>
</tr>
<tr>
<td>Math 132</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>Math 233</td>
<td>Calculus III</td>
<td>3</td>
</tr>
<tr>
<td>Math 309</td>
<td>Matrix Algebra</td>
<td>3</td>
</tr>
<tr>
<td>Math 3211</td>
<td>Statistics for Data Science I</td>
<td>3</td>
</tr>
<tr>
<td>Math 4211</td>
<td>Statistics for Data Science II</td>
<td>3</td>
</tr>
<tr>
<td>Math 439</td>
<td>Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>CSE 131</td>
<td>Introduction to Computer Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 247</td>
<td>Data Structures and Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 217A</td>
<td>Introduction to Data Science</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 314A</td>
<td>Data Manipulation and Management</td>
<td>3</td>
</tr>
<tr>
<td>CSE 417T</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(or Math 4601 Statistical Learning)</td>
<td></td>
</tr>
</tbody>
</table>

Total Units 36

Data Science Technical Electives

Four courses from Mathematics & Statistics or Computer Science & Engineering can be chosen from an approved list, with the following caveats:

- At least one course from Mathematics & Statistics (at the 400 level or above)
- At least one course from CSE (ending in S, T, M, or A)
- At most one course at the 200 level

List of Approved Data Science Technical Electives

Computer Science and Engineering

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSE 237S</td>
<td>Programming Tools and Techniques</td>
<td>3</td>
</tr>
<tr>
<td>CSE 256A</td>
<td>Introduction to Human-Centered</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Design</td>
<td></td>
</tr>
<tr>
<td>CSE 311A</td>
<td>Introduction to Intelligent Agents</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Using Science Fiction</td>
<td></td>
</tr>
<tr>
<td>CSE 347</td>
<td>Analysis of Algorithms</td>
<td>3</td>
</tr>
<tr>
<td>CSE 359A</td>
<td>Signals, Data and Equity (Cannot be double-counted in EPR)</td>
<td>3</td>
</tr>
<tr>
<td>CSE 411A</td>
<td>AI and Society (Cannot be double-counted in EPR)</td>
<td>3</td>
</tr>
<tr>
<td>CSE 412A</td>
<td>Introduction to Artificial Intelligence</td>
<td>3</td>
</tr>
<tr>
<td>CSE 416A</td>
<td>Analysis of Network Data</td>
<td>3</td>
</tr>
<tr>
<td>CSE 417T</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(Cannot be double-counted in CR)</td>
<td></td>
</tr>
<tr>
<td>CSE 427S</td>
<td>Cloud Computing with Big Data Applications</td>
<td>3</td>
</tr>
<tr>
<td>CSE 435S</td>
<td>Database Management Systems</td>
<td>3</td>
</tr>
<tr>
<td>CSE 457A</td>
<td>Introduction to Visualization</td>
<td>3</td>
</tr>
<tr>
<td>CSE 514A</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>CSE 515T</td>
<td>Bayesian Methods in Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CSE 517A</td>
<td>Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>CSE 518A</td>
<td>Human-in-the-Loop Computation</td>
<td>3</td>
</tr>
<tr>
<td>CSE 534A</td>
<td>Large-Scale Optimization for Data Science</td>
<td>3</td>
</tr>
<tr>
<td>CSE 543T</td>
<td>Algorithms for Nonlinear Optimization</td>
<td>3</td>
</tr>
<tr>
<td>CSE 559A</td>
<td>Computer Vision</td>
<td>3</td>
</tr>
</tbody>
</table>
### Mathematics and Statistics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 322</td>
<td>Biostatistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 420</td>
<td>Experimental Design</td>
<td>3</td>
</tr>
<tr>
<td>Math 434</td>
<td>Survival Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 4392</td>
<td>Advanced Linear Statistical Models</td>
<td>3</td>
</tr>
<tr>
<td>Math 449</td>
<td>Numerical Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 450</td>
<td>Topics in Applied Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 456</td>
<td>Topics in Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>Math 459</td>
<td>Bayesian Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 460</td>
<td>Multivariate Statistical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 461</td>
<td>Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>Math 4601</td>
<td>Statistical Learning (Cannot be double-counted in CR)</td>
<td>3</td>
</tr>
<tr>
<td>Math 462</td>
<td>Mathematical Foundations of Big Data</td>
<td>3</td>
</tr>
<tr>
<td>Math 475</td>
<td>Statistical Computation</td>
<td>3</td>
</tr>
<tr>
<td>Math 493</td>
<td>Probability</td>
<td>3</td>
</tr>
<tr>
<td>Math 494</td>
<td>Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>Math 495</td>
<td>Stochastic Processes</td>
<td>3</td>
</tr>
<tr>
<td>Math 5047</td>
<td>Geometry/Topology III: Differential Geometry</td>
<td>3</td>
</tr>
<tr>
<td>Math 5061</td>
<td>Theory of Statistics I</td>
<td>3</td>
</tr>
<tr>
<td>Math 5062</td>
<td>Theory of Statistics II</td>
<td>3</td>
</tr>
<tr>
<td>Math 5071</td>
<td>Linear Statistical Models Grad</td>
<td>3</td>
</tr>
<tr>
<td>Math 5072</td>
<td>Advanced Linear Models II</td>
<td>3</td>
</tr>
</tbody>
</table>

### Ethics and Professional Responsibility Requirement (EPR)

- 3 units of courses from the following list:

#### List of EPR Course Options

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engr 330</td>
<td>Amplifying Cyberdiversity: Real Humans in Virtual Spaces</td>
<td>3</td>
</tr>
<tr>
<td>Engr 4501</td>
<td>Engineering Ethics and Sustainability</td>
<td>1</td>
</tr>
<tr>
<td>Engr 4502</td>
<td>Engineering Leadership and Team Building</td>
<td>1</td>
</tr>
<tr>
<td>Engr 4503</td>
<td>Conflict Management and Negotiation</td>
<td>1</td>
</tr>
<tr>
<td>Engr 450F</td>
<td>Engineers in the Community (Engineering Ethics, Leadership and Conflict Management)</td>
<td>3</td>
</tr>
<tr>
<td>Engr 520P</td>
<td>Presentation Skills for Scientists and Engineers</td>
<td>2</td>
</tr>
<tr>
<td>CSE 359A</td>
<td>Signals, Data and Equity (Cannot be double-counted as an Elective)</td>
<td>3</td>
</tr>
<tr>
<td>CSE 411A</td>
<td>AI and Society (Cannot be double-counted as an Elective)</td>
<td>3</td>
</tr>
<tr>
<td>MSB 512</td>
<td>Ethics in Biostatistics and Data Science</td>
<td>2</td>
</tr>
</tbody>
</table>

### Electrical and Systems Engineering

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESE 4031</td>
<td>Optimization for Engineered Planning, Decisions and Operations</td>
<td>3</td>
</tr>
<tr>
<td>ESE 415</td>
<td>Optimization</td>
<td>3</td>
</tr>
<tr>
<td>ESE 427</td>
<td>Financial Mathematics</td>
<td>3</td>
</tr>
</tbody>
</table>

### Energy, Environmental & Chemical Engineering

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECE 202</td>
<td>Computational Modeling in Energy, Environmental and Chemical Engineering</td>
<td>3</td>
</tr>
</tbody>
</table>

### Linguistics

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ling 317</td>
<td>Introduction to Computational Linguistics</td>
<td>3</td>
</tr>
</tbody>
</table>
Notes to All Majors in Mathematics and Statistics

1. Upper-level mathematics courses are those with course numbers that begin with a 3 or higher (e.g., Math 3200). Lower-level courses do not count toward upper-level mathematics requirements, even if they are cross-listed as an upper-level course in another department or program. For example, if Math 2200 were cross-listed by another department as 3XXX, then registering for that 3XXX course would not satisfy an upper-level mathematics requirement.

2. All required courses (both lower- and upper-level courses) must be completed with a grade of C- or better.

3. Math 318 and Math 308 cannot both be used to fulfill major requirements.

4. Courses transferred from other accredited colleges and universities with department approval can be counted, with the following caveats:
   a. Courses transferred from a two-year college (e.g., a community college) cannot be used to satisfy upper-level requirements.
   b. At least half the upper-level units required in a major must be earned at Washington University or in a Washington University-approved overseas study program.
   c. Courses from University College cannot be used to fulfill major requirements.

5. At most 3 units of independent study or research work can count toward the major requirements.

6. No upper-level course used to satisfy a major requirement can be counted toward the requirements of any other major or minor (i.e., no double-counting of courses).

7. Certain approved substitutions are found on the Department of Mathematics and Statistics webpage (https://math.wustl.edu/major-and-minor-details/). However, in all cases, at most one substitution can be used that involves a course not home-based in the department.

8. A student may declare at most one major or minor in any department. This includes joint majors such as Mathematics and Computer Science and Mathematics and Economics.

9. At most 3 units from a different department at WashU can count toward the major requirements.

Additional Information

Additional Requirements

- All mathematics majors must take Math 131 Calculus I, Math 132 Calculus II, and Math 233 Calculus III. There are other ways to fulfill this requirement, including AP credit and Math 203 Honors Mathematics I-Math 204 Honors Mathematics II. Some students may obtain a waiver if they took similar courses before coming to Washington University.

- All required courses must be completed with a letter grade of C- or better.

- University College courses cannot be counted toward major requirements.

- No double-counting of upper-level courses with other majors or minors is allowed.

- At most 3 units for independent study or research work can count toward the major requirements.

- At most 3 units from a different department at Washington University can count toward the major requirements.

- Courses transferred from other accredited colleges and universities can be counted toward a major or minor with departmental approval.

- At least half of the upper-level credits required in a mathematics major or minor program must be fulfilled by Department of Mathematics and Statistics courses taken at Washington University or in Washington University–approved overseas study programs.

- A student cannot declare more than one major or minor in the department. This includes joint majors such as Mathematics and Economics, Mathematics and Computer Science, and Data Science. These majors count as in the department even if they are declared in another department.

Course Substitutions

At most one approved substitution can be made using a course not home-based in the Department of Mathematics and Statistics. Please note the policy that at most one course from a different department at Washington University can count toward a major or minor.

- ESE 326 can be taken in place of Math 3200. ESE 326 and Math 3200 cannot both count toward a major or minor.

- Any course from another department that is cross-listed as a mathematics L24 course can count as an upper-level elective. Examples include L24 501C, L24 440C, and L24 403C. Such L24 courses always end with a “C.”

- The following courses can count as upper-level mathematics electives:
  - L30 Phil 401, Phil 403, and Phil 404
  - Econ 4151 (this course can count as a statistics elective)
  - ESE 319, ESE 403, and ESE 411
Courses in Probability and Statistics

The major and minor in statistics require electives in probability and statistics. Below is the list of allowed such courses:

- Math 3200 Elementary to Intermediate Statistics and Data Analysis
- Math 3211 Statistics for Data Science I
- Math 322 Biostatistics
- Math 420 Experimental Design
- Math 434 Survival Analysis
- Math 439 Linear Statistical Models
- Math 4392 Advanced Linear Statistical Models
- Math 459 Bayesian Statistics
- Math 460 Multivariate Statistical Analysis
- Math 461 Time Series Analysis
- Math 462 Mathematical Foundations of Big Data
- Math 475 Statistical Computation
- Math 493 Probability
- Math 494 Mathematical Statistics
- Math 495 Stochastic Processes
- Math 496: Topics In Statistics

* Math 3200 and Math 3211 cannot both be counted toward a major.

Distinctions in Mathematical Sciences, Mathematics, Applied Mathematics and Statistics

Distinction

- Complete at least 33 units of upper-level mathematics and/or statistics courses.
- The GPA for these 33 upper-level units must be at least 3.7. If more than 33 units are taken for a letter grade, then the courses with the lowest grades can be omitted when computing GPA for this purpose.
- Complete at least five courses, each with a B or better, at level 400+.
- All of these courses must be classroom courses (not independent study or study for honors), and they must all be taken for a letter grade.

High Distinction

- Complete all requirements for Distinction.
- Complete an honors thesis.

Highest Distinction

- Complete all requirements for High Distinction.
- Complete at least five courses, each with a grade of B+ or better, at the 400 level or higher. These can be the same five courses used for the Distinction requirement, but the grades must be B+ or better.
- Complete one of the two paths described below:
  - Graduate Qualifier Path: Graduate qualifier courses in mathematics and statistics are two-semester sequences that start in the fall. In mathematics, a two-semester graduate qualifier sequence has a qualifier exam at the end of each semester. In statistics, a two-semester sequence has a qualifier exam only at the end of the sequence in spring. Students must complete and pass one of the following:
    a. Two semesters of qualifier courses* and their corresponding exams in mathematics (These courses can involve a single year-long sequence or be the first semesters of two different sequences.)
    b. One full-year qualifier course sequence* and its corresponding exam in statistics
  - Course Work Path:
    1. Complete at least 42 units of upper-level mathematics and/or statistics courses. The GPA for these 42 upper-level units must be at least 3.7. If more than 42 units are taken for a letter grade, then the courses with the lowest grades can be omitted when computing GPA for this purpose.
    2. Complete at least nine total courses at the 400 level or above, all with a B+ or better. These can include the five courses taken for distinction. All of these courses must be classroom courses (not independent study or study for honors), and they must all be taken for a letter grade.

* These qualifier courses can count toward the additional course requirements for Distinction.

Distinctions in Mathematics and Computer Science

Distinction

- For Distinction in Mathematics and Computer Science, a student must take an additional two electives, for a total of 10 electives.
- The student's GPA in the 10 electives must be at least 3.7. If the student takes additional courses that satisfy these requirements, then the courses with the lowest grades may be omitted when calculating GPA for this purpose.
• The student must complete at least four courses from the list of approved courses, each with a grade of B or better. These courses can be in either department (i.e., Mathematics and Statistics or Computer Science & Engineering). The list of courses will be maintained by both departments. Current approved courses include the following:
• All of the above courses must be classroom courses (not independent study).

High Distinction
• Complete all requirements for Distinction.
• Complete an honors thesis in either department (Mathematics and Statistics or Computer Science & Engineering).

Highest Distinction
• Complete the requirements for High Distinction.
• Complete one of the two options described below:
  • Qual Option: Complete two semesters of graduate course work and qualifier exams in the Department of Mathematics and Statistics, as described above for Highest Distinction for mathematics and statistics majors.
  • Course Option: Complete three additional electives, for a total of 13. As with Distinction, the student's GPA in the 13 electives must be at least 3.7, and additional courses beyond 13 can be disregarded when calculating the GPA. The 13 electives must include at least eight courses selected from the list under Distinction, each with a grade of B+ or better. At least two of these eight courses must be from each department (Mathematics and Statistics and Computer Science & Engineering).

Latin Honors
At the time of graduation, the Department of Mathematics and Statistics will recommend that a candidate receive Latin Honors (cum laude, magna cum laude, or summa cum laude) if that student has completed the department's requirements for High Distinction or Highest Distinction in Mathematics, each of which requires an Honors Thesis. The actual award of Latin Honors is managed by the College of Arts & Sciences.

The Honors Thesis
Arts & Sciences mathematics and statistics majors who want to be candidates for Latin Honors, High Distinction, or Highest Distinction must complete an honors thesis. Writing an honors thesis involves a considerable amount of independent work, reading, creating mathematics, writing a paper that meets acceptable professional standards, and making an oral presentation of results.

Types of Projects
An honors thesis can take three forms:
1. A thesis that presents significant work by the student on one or more nontrivial mathematics problems.
2. A project in mathematical or applied statistics that involves an in-depth analysis of a large data set. To do an honors thesis involving data analysis, it is usually necessary to have completed Math 3200-Math 493-Math 494 by the end of the junior year and to have the ability to work with statistical software such as SAS, R, or Python.
3. A substantial expository paper that follows independent study on an advanced topic under the guidance of a department faculty member. Such a report would involve the careful presentation of ideas and the synthesis of materials from several sources.

Process and Suggested Timeline
Junior Year, Spring Semester:
1. Talk with a faculty advisor about possible projects.
2. Complete the Honors Proposal Form and submit it to Blake Thornton.

Senior Year:
1. By the end of January, provide the advisor with a draft abstract and outline of the paper.
2. By the end of February, submit a rough draft, including an abstract, to the advisor.
3. The student and the advisor should agree on a date that the writing will be complete and on a data and time for the oral presentation in mid-March (the deadline is March 31).

Departmental Prizes
Each year, the department considers graduating majors for three departmental prizes. Recipients are recognized at an annual awards ceremony in April, where they each receive a certificate and a set of honors cords to be worn as part of the academic dress at Commencement. Awards are noted on the student's permanent university record.
Ross Middlemiss Prize
The Ross Middlemiss Prize is awarded to a graduating math major with an outstanding record. The award was established by former Professor Ross Middlemiss, who taught at Washington University for 40 years. From 1936 through the 1960s, Middlemiss authored several books, including a widely popular calculus text that was used in University College courses until the late 1970s.

Putnam Exam Prize
The Putnam Exam Prize is awarded to a graduating senior who has participated regularly in the Putnam Exam Competition and done exceptionally well throughout their time at Washington University.

Martin Silverstein Award
The Martin Silverstein Award was established in memory of Professor Martin Silverstein, who, until his death in 2004, was a pioneer in work at the interface of probability theory and harmonic analysis. Each year, the department considers for this award students in any major track, but especially those with strengths in probability or statistics.

Brian Blank Award
The Brian Blank Award was established in memory of Professor Brian Blank, who passed away in 2018. Each year, the Department of Mathematics and Statistics selects for this prize distinguished junior(s) majoring in mathematics and statistics.