Lower Division General Education

- Composition  * 6
- Oral Communication  3
- Mathematics (met in the major by MATH 211)  0-6
- Language and Culture  0-6
- Information Literacy and Research  3
- CS 121G Introduction to Information Literacy and Research for Scientists (preferred)  ** 3
- Human Creativity  3
- Interpreting the Past  3
- Literature  3
- Human Behavior  *** 3
- Philosophy and Ethics (PHIL 120P recommended)  3
- The Nature of Science  * 8
- Impact of Technology  ** 3

Total Hours  38-44

* A grade of C or better is required in both courses.

** IT 150G is an acceptable substitute for the Actuarial Mathematics major or the Big Data Analytics major.

*** ECON 202S is required for the Actuarial Mathematics major.

Bachelor of Science in Mathematics

The Department of Mathematics and Statistics offers programs of study that lead to the degree of Bachelor of Science in Mathematics. A student can earn the degree by completing a major in Applied Mathematics, a major in Statistics/Biostatistics, a major in Actuarial Mathematics, or a major in Big Data Analytics. Students can also earn a degree of Bachelor of Science in Mathematics with Teaching Licensure, which is intended for those who wish to pursue a career in teaching mathematics at the high school level and leads to teaching licensure in the Commonwealth of Virginia. The applied mathematics major is intended for students wishing to pursue graduate work in mathematics or otherwise obtain employment in a mathematics field. Similarly, the statistics/biostatistics major is intended for those who wish to pursue graduate work in statistics or otherwise obtain employment in a statistics-related field, especially biostatistics. The actuarial mathematics major is specifically designed for students who wish to pursue an actuarial field, pursue graduate work in financial mathematics, or employment in a mathematics or statistics-related field. The big data analytics major is designed for students wishing to pursue one of the many jobs that require solving important large-scale problems in applied sciences, engineering, business, industry and government as well as pursue graduate work in big data analytics. Teaching licensure can also be added to any of the majors above, which automatically fulfills the University’s upper-division general education requirement under Option C.

The upper-division general education requirement must be satisfied by completing a Finance major with Risk Management and Insurance concentration (Option A) or by completing a Finance minor in Risk Management and Insurance (Option B).

Requirements

Lower Division General Education

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 311W</td>
<td>Abstract Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 317</td>
<td>Calculus IV: Introductory Analysis</td>
<td>3</td>
</tr>
<tr>
<td>STAT 310</td>
<td>Introductory Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 330</td>
<td>An Introduction to Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 331</td>
<td>Theory of Probability</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 34

* A grade of C+ or higher is required in MATH 211 and MATH 212. A cumulative GPA of 2.3 or higher is required in all 300 and 400 level core courses with no grade lower than a C. In addition, a grade of C or higher is required in mathematics and statistics prerequisite courses to advance to the next course.

** Statistics/Biostatistics majors and Actuarial Mathematics majors must take both.

*** Statistics/Biostatistics majors and Actuarial Mathematics majors take STAT 331.

All students earning a B.S. in Mathematics are required to choose one of the following majors or complete the teaching licensure requirements.

Major in Applied Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 401</td>
<td>Partial Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 408</td>
<td>Applied Numerical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 422</td>
<td>Applied Complex Variables</td>
<td>3</td>
</tr>
<tr>
<td>MATH 400-level electives:</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>MATH 400</td>
<td>History of Mathematics</td>
<td></td>
</tr>
<tr>
<td>MATH 404</td>
<td>Fundamental Concepts of Geometry</td>
<td></td>
</tr>
<tr>
<td>MATH 406</td>
<td>Number Theory and Discrete Mathematics</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 18

Major in Statistics/Biostatistics

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 310</td>
<td>Introductory Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 405</td>
<td>Introduction to Data Handling</td>
<td>3</td>
</tr>
<tr>
<td>STAT 400-level electives</td>
<td></td>
<td>12</td>
</tr>
</tbody>
</table>

Total Hours 18

Major in Actuarial Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 311</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 311W</td>
<td>Abstract Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>MATH 317</td>
<td>Calculus IV: Introductory Analysis</td>
<td>3</td>
</tr>
<tr>
<td>STAT 310</td>
<td>Introductory Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 330</td>
<td>An Introduction to Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 331</td>
<td>Theory of Probability</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours 34
Minimum required grade point averages (GPA).

The Virginia Board of Education prescribed assessments and earn the required in all 300 and 400 level mathematics core courses with no grade lower than a C-.

Two courses from the following list with at least one being a STAT course required in all 300 and 400 level core courses with no grade lower than a C-.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 310</td>
<td>Introductory Data Analysis</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 405</td>
<td>Introduction to Data Handling</td>
<td>3</td>
</tr>
<tr>
<td>STAT 437</td>
<td>Applied Regression and Time Series Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MATH 408</td>
<td>Applied Numerical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>MATH 401</td>
<td>Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 409</td>
<td>Applied Numerical Methods II</td>
<td></td>
</tr>
<tr>
<td>MATH 417</td>
<td>Intermediate Real Analysis I</td>
<td></td>
</tr>
<tr>
<td>STAT 432</td>
<td>Sampling Theory</td>
<td></td>
</tr>
<tr>
<td>STAT 449</td>
<td>Nonparametric Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 450</td>
<td>Categorical Data Analysis</td>
<td></td>
</tr>
<tr>
<td>STAT 460</td>
<td>Statistical Simulation/Programming Using Statistical Software Packages</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours: 18

Major in Big Data Analytics

The upper-division general education requirement must be satisfied by completing a minor or second major in computer science, which includes CS 361 Advanced Data Structures and Algorithms.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 405</td>
<td>Introduction to Data Handling</td>
<td>3</td>
</tr>
<tr>
<td>BDA 411</td>
<td>Introduction to Machine Learning</td>
<td>3</td>
</tr>
<tr>
<td>BDA 431</td>
<td>Data Mining</td>
<td>3</td>
</tr>
<tr>
<td>BDA 432</td>
<td>Introduction to Optimization and Inverse Problems</td>
<td>3</td>
</tr>
<tr>
<td>BDA 450</td>
<td>Senior Project in Big Data Analytics I (At least three of the following courses:)</td>
<td>3</td>
</tr>
<tr>
<td>STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
<tr>
<td>STAT 437</td>
<td>Applied Regression and Time Series Analysis</td>
<td></td>
</tr>
<tr>
<td>MATH 401</td>
<td>Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 408</td>
<td>Applied Numerical Methods I</td>
<td></td>
</tr>
<tr>
<td>MATH 421</td>
<td>Applied Mathematics II: Mathematical Modeling</td>
<td></td>
</tr>
<tr>
<td>BDA 413</td>
<td>Modern Statistical Methods for Big Data Analysis</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours: 24

Elective Credit

Elective credit may be needed to meet the minimum requirement of 120 credit hours for all students earning a B.S. in Mathematics.

Bachelor of Science in Mathematics with Teaching Licensure

Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, all education courses must be passed with a grade of C- or higher. A grade of C+ or higher is required in MATH 211 and MATH 212, and a cumulative GPA of 2.3 or higher is required in all 300 and 400 level core courses with no grade lower than a C. No grade lower than C- is accepted for the remaining math courses.

A professional education GPA of 2.75 is required. All professional education courses must be passed with a grade of C- or higher.

Although students may enroll in a limited number of education courses, students must be admitted into the approved mathematics teacher preparation program prior to enrolling in any instructional strategies practicum education course. Students must also meet with an education advisor in the MonarchTeach Office.

Continuance

Students must maintain a cumulative GPA of 2.75, a major/content GPA of 2.75 and a professional education GPA of 2.75. The mathematics core must be successfully completed. A grade of C+ or higher is required in MATH 211 and MATH 212, and a cumulative GPA of 2.3 or higher is required in all 300 and 400 level mathematics core courses with no grade lower than a C-.

Required grade point averages (GPA)

- A cumulative GPA of 2.75 is required.
- A major/content GPA of 2.75 is required. The mathematics core must be successfully completed. A grade of C+ or higher is required in MATH 211 and MATH 212, and a cumulative GPA of 2.3 or higher is required in all 300 and 400 level core courses with no grade lower than a C. No grade lower than C- is accepted for the remaining math courses.
- A professional education GPA of 2.75 is required. All professional education courses must be passed with a grade of C- or higher.

Virginia Board of Education prescribed assessments:

Old Dominion University students seeking admission to an approved teacher education program must satisfy the Virginia Board of Education Required Assessment for Admission to an Approved Teacher Education Program. This requirement can be satisfied by meeting a passing score in one of the selected criteria below:

1. Passing Praxis I composite score of 532 by December 31, 2013; or
2. Passing Praxis Core Academic Skills Tests beginning January 1, 2014: Reading Score of 156, Writing Score of 162, and Mathematics Score of 150; or
3. Approved substitute test scores:
   a. SAT score of 1000 with at least 450 verbal and 510 mathematics taken prior to April 1, 1995; or
   b. SAT score of 1100 with at least 530 verbal and 530 mathematics taken after April 1, 1995 and before March 2016; or
   c. ACT composite score of 21 with ACT mathematics score of at least 21, and ACT English plus Reading score of at least 37, taken prior to April 1, 1995; or
   d. ACT composite score of 24 with ACT mathematics score of at least 22, and ACT English plus Reading score of at least 46, taken after April 1, 1995; or
   e. Praxis I Math test score of 178 by December 31, 2013 and a composite Virginia Communication and Literacy Assessment (hereafter referred to as the VCLA) score of 470; or
   f. Praxis Core Academic Skills Mathematics test score of 150 beginning January 1, 2014 and a VCLA score of 470; or
   g. SAT Mathematics test score of at least 510 taken prior to April 1, 1995 and a VCLA score of 470; or
   h. SAT Mathematics test score of at least 530 taken after April 1, 1995 and a composite VCLA score of 470; or
   i. ACT Mathematics test score of at least 21 taken prior to April 1, 1995 and a composite VCLA score of 470; or
   j. ACT Mathematics test score of at least 22 taken after April 1, 1995 and a composite VCLA score of 470.

Note: ACT scores taken prior to 1989 are not valid.

For the most current information on the prescribed Virginia Board of Education admission assessment, visit the Teacher Education Services website, http://www.odu.edu/tes and review the Teacher Education Handbook.

Mathematics and Statistics
lower than a C. The remaining courses required for the major and in the professional education core must be completed with a grade of C- or higher for continuance. A professional education GPA of 2.75 is required for continuance. Students must take and pass the Virginia Communication and Literacy Assessment (VCLA) and the Praxis Subject Assessment, Mathematics content knowledge (formerly Praxis II) prior to or while enrolled in the instructional strategies course. All assessments must be passed prior to the start of the Teacher Candidate Internship Orientation session.

Background Clearance Requirement
Old Dominion University requires a background clearance check of candidates interested in many of the professional education programs. Professional education programs have several field experiences that are required for continuance and graduation from the program. The background clearance must be successfully completed prior to a field experience placement. Candidates will be provided a field experience placement when the background check process is completed with resolution of any issues. The process to complete the ODU clearance background check is located at: http://www.odu.edu/success/academic/teacher-education/placement/background-checks. The ODU clearance process includes: an FBI fingerprint, a child protective service/social service review, and a Virginia State Police sex offender registry review. Candidates interested in the professional education programs are advised to complete this clearance process immediately upon entry into the program since the clearance process takes a minimum of eight weeks to complete.

Virginia Board of Education prescribed assessments
Virginia Communication and Literacy Assessment (VCLA) – a passing composite score of 470 is required on this reading and writing assessment
Praxis Subject Assessment, Mathematics content knowledge (formerly Praxis II). Test code: 5161 – passing score of 160 is required

To review more information on the Virginia Board of Education prescribed assessments visit the Teacher Education Services website, www.odu.edu/tes.

Graduation
Requirements for graduation with a B.S. in Mathematics with Teaching Licensure include completion of ENGL 110C and ENGL 211C or ENGL 221C or ENGL 231C with a grade of C or better, completion of the Senior Assessment, a minimum cumulative 2.75 GPA, in the major area, and in the professional education core, successful completion of the mathematics core, no grade less than C- in the remaining courses in the major and the professional education core, successful completion of the Apprentice Teaching, and a minimum of 120 credit hours to include a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, and in the professional education core, core requirements of the mathematics core, no grade less than C- in the remaining courses in the major and the professional education core, core requirements of the Apprentice Teaching, and a minimum of 120 credit hours to include a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University. Successful completion of the core requires a grade of C or higher in MATH 211 and MATH 212, and a cumulative GPA of 2.3 or higher is required in all 300 and 400 level mathematics core courses with no grade lower than a C.

Course Requirements for the B.S. in Mathematics with Teaching Licensure

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 375</td>
<td>Advanced Concepts for Secondary Educators: Function and Modeling</td>
<td>3</td>
</tr>
<tr>
<td>MATH 400</td>
<td>History of Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>MATH 404</td>
<td>Fundamental Concepts of Geometry</td>
<td>3</td>
</tr>
<tr>
<td>MATH 406</td>
<td>Number Theory and Discrete Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>MATH 417</td>
<td>Intermediate Real Analysis I</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>or MATH 422 Applied Complex Variables</td>
<td></td>
</tr>
<tr>
<td>MATH 400-level electives</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total Hours</td>
<td>21</td>
</tr>
</tbody>
</table>

Professional Education core courses and requirements

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM 101</td>
<td>Step 1 – Inquiry Approaches to Teaching STEM</td>
<td>1</td>
</tr>
</tbody>
</table>

Upper-Division General Education
The professional education core satisfies this requirement for students earning a B.S. in Mathematics with Teaching Licensure. Students majoring in Actuarial Mathematics must complete a major or a minor in Finance with a concentration in Risk Management and Insurance to meet upper-division general education requirements. Students majoring in Big Data Analytics must complete a major or a minor in Computer Science, which includes CS 361 in order to meet upper-division general education requirements.

- Option A. Approved Disciplinary Minor (a minimum of 12 hours determined by the department), or second degree or second major. A double major within the Department of Mathematics and Statistics will not satisfy the University’s upper-division general education requirement under option A except for a double major in applied mathematics and statistics/biostatistics.
- Option B: Interdisciplinary Minor (specifically 12 hours, 3 of which may be in the major)
- Option C. International Business and Regional Courses or an approved Certification Program such as teaching licensure
- Option D: Two Upper-Division Courses from outside the College of Sciences and not required by the major (6 hours)

Requirements for Graduation
Requirements for graduation for students majoring in applied mathematics, statistics/biostatistics, big data analytics and actuarial mathematics include a minimum cumulative grade point average of 2.00 overall and in the major with successful completion of the mathematics core, 120 credit hours, which must include both a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University, and in the professional education core, core requirements of the mathematics core, no grade less than C- in the remaining courses in the major and the professional education core, core requirements of the Apprentice Teaching, and a minimum of 120 credit hours to include a minimum of 30 credit hours overall and 12 credit hours in upper-level courses in the major program from Old Dominion University. Successful completion of the core requires a grade of C or higher in MATH 211 and MATH 212, and a cumulative GPA of 2.3 or higher is required in all 300 and 400 level mathematics core courses with no grade lower than a C.

Practicum
Any student who wishes to receive a practicum or internship experience may do so as an integral part of the degree program. Students in the secondary school teacher track are required to complete both a practicum and a student teaching internship as part of the degree requirements. Otherwise, students may substitute the practicum experience for one of the optional courses listed in the other majors.

Minor in Mathematics
Students may pursue a minor in mathematics with an emphasis in one of the three following areas: applied mathematics, statistics/biostatistics or actuarial mathematics.

The applied mathematics option consists of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 317</td>
<td>Calculus IV: Introductory Analysis</td>
<td>3</td>
</tr>
</tbody>
</table>

Select two of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td></td>
</tr>
<tr>
<td>MATH 401</td>
<td>Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MATH 408</td>
<td>Applied Numerical Methods I</td>
<td></td>
</tr>
<tr>
<td>MATH 409</td>
<td>Applied Numerical Methods II</td>
<td></td>
</tr>
<tr>
<td>MATH 417</td>
<td>Intermediate Real Analysis I</td>
<td></td>
</tr>
</tbody>
</table>
The statistics/biostatistics option consists of 12 hours of statistics at the 300/400 level, of which at most six hours can be at the 300 level. STAT 306 cannot be applied to this option.

The actuarial mathematics option consists of the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 316</td>
<td>Introductory Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>STAT 330</td>
<td>An Introduction to Probability and Statistics</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 331</td>
<td>Theory of Probability</td>
<td></td>
</tr>
<tr>
<td>or MATH 408</td>
<td>Applied Numerical Methods I</td>
<td>3</td>
</tr>
<tr>
<td>or STAT 431</td>
<td>Theory of Statistics</td>
<td></td>
</tr>
</tbody>
</table>

Total Hours: 13

At least nine credit hours in the chosen option must be taken through courses offered by Old Dominion University. Students must have an overall grade point average of at least 2.00 in the courses required for the minor in their chosen option exclusive of 100/200-level courses and prerequisite courses.

Advanced Placement

Students who have achieved a qualifying score on the Calculus AB or Calculus BC advanced placement examinations receive credit for MATH 211 (and MATH 162M and MATH 163). Credit for MATH 162M and MATH 163 is also given for qualifying scores on the placement tests administered by the University Testing Center. Refer to the Academic Testing and the Prior Learning Assessment Credit Options at the Undergraduate Level sections of this Catalog. Advanced placement credit is not available for MATH 102M.

Linked Bachelor of Science in Mathematics and Master of Science in Computational and Applied Mathematics

The linked program allows students to count up to 12 credits of graduate coursework toward both their undergraduate and master's degrees. Students must earn a minimum of 150 credits (120 for the undergraduate degree and 30 for the graduate degree).

Admission

To be admitted to the linked program, students must have completed at least 60 undergraduate credit hours with at least 24 credit hours from ODU. Students must have completed MATH 307, MATH 312, MATH 317 and all prerequisites for those courses. At the time of admission, they must have an overall GPA of 3.00 or better and a GPA of 3.00 or better in MATH and STAT courses.

Interested students who meet the admission requirements should apply to the graduate program director, after consulting with the undergraduate chief departmental advisor, as soon as possible upon completing the required courses and 60 credit hours. In consultation with the graduate program director, a student will:

1. Officially declare an undergraduate Mathematics major with the undergraduate chief departmental advisor.
2. Draft a schedule of graduate courses to be taken as an undergraduate to be presented to the undergraduate chief departmental advisor.
3. Apply, during their senior year, to the Office of Graduate Admissions for admission to the master's in computational and applied mathematics program.

Students who have completed at least six hours of graduate courses upon attaining senior standing (completion of 90 credit hours) and who have earned a GPA of 3.00 or better in those courses will not be required to take the Graduate Record Exam (GRE) for admission to the master's program. Otherwise, in keeping with normal admission requirements for the M.S. in computational and applied mathematics, students will take the GRE as an undergraduate and will subsequently be reevaluated for continuation into the master's program.

Once students have been awarded their bachelor's degree and fulfilled all regular admission requirements for the M.S. in computational and applied mathematics, they will be officially admitted into the M.S. program.

Program Requirements

Students in the program will fulfill all normal admission and curricular requirements for both a B.S. in mathematics and an M.S. in computational and applied mathematics with the following exceptions:

1. Students in the program may count up to 12 hours of 500 or 600 level graduate courses, excluding independent study, taken as an undergraduate for which they have earned a grade point average of 3.0 or greater with no course grade lower than a B- toward both the B.S. in mathematics and the M.S. in computational and applied mathematics.
2. Students in the program may substitute mathematics or statistics graduate courses for undergraduate courses according to the following schema. All students must complete an undergraduate writing intensive course in the major.
   a. All students must complete the prescribed undergraduate program including all 400-level required courses and electives.
   b. All students may substitute 500- and 600-level courses for the remaining credit hours in the 120-hour requirement in the undergraduate program so long as they have the prerequisites for those courses. 700- or 800-level courses may not be used.
   c. Students will not receive credit for both the 400 and 500 level version of the same course.
   d. Students in the program may make a written petition for other substitutions to the graduate program director, who will consider them in consultation with the chief departmental advisor and the instructor(s) of the courses involved.

NOTES:

1. In accordance with University policy, up to 21 hours of graduate courses taken as an undergraduate may be counted toward the bachelor's degree; however, only 12 hours of graduate courses taken as an undergraduate may also be counted toward the M.S. degree. This will limit students' scheduling flexibility subsequently.

BIG DATA ANALYTICS Courses

BDA 411/511. Introduction to Machine Learning. 3 Credits.

An introductory course on machine learning. The course gives an elementary summary of modern machine learning tools. Topics include regression, decision trees, artificial neural networks, genetic algorithms, clustering, dimension-reduction, learning sets of rules, support vector machines, hidden Markov models, and Bayesian learning. The course will also discuss applications of machine learning that include data mining, bioinformatics, speech recognition, and text and web data processing. Students enrolled are expected to have some ability to write computer programs, some knowledge of probability, statistics and linear algebra. Prerequisites: MATH 312, MATH 316, and STAT 331.
BDA 413/513. Modern Statistical Methods for Big Data Analysis. 3 Credits.
Due to the rapid development of technology, vast amount of data is being
generated in social media, genomics, financial industry, business and health
care. We rely increasingly on statistical tools to analyze this big data. From
the vast array of tools available, in this course students will study the most
relevant ones. Topics that will be covered are Logistic Regression, Lasso
and Related Methods, Support Vector and Kernel Methodology, Principal
Components (SVD) and Variations, Multidimensional Scaling, Boosting,
Random Forests, Graphical Models, False Discovery Rates and Permutation
Tests. Prerequisites: A grade of C or better in STAT 331 and STAT 405.

BDA 431/531. Data Mining. 3 Credits.
Data mining is the science of discovering structure and making predictions
in data sets. Data Mining is a dynamic and fast growing field at the interface
of Statistics and Computer Science. The statistical perspective of data
mining is emphasized for the majority of the course. Both applied aspects
(programming, problem solving, and data analysis) and theoretical concepts
(learning, understanding, and evaluating methodologies) of data mining will
be covered. Topics may include data preparation, data cleaning, exploratory
data analysis, statistical estimation and prediction, regression modeling,
clustering, classification and regression trees. An elementary knowledge of
concepts in probability and statistics and basic computing proficiency are
required. Prerequisites: A grade of C or better in STAT 331 and STAT 405.

BDA 432/532. Introduction to Optimization and Inverse Problems. 3 Credits.
Topics considered include unconstrained and constrained optimization
problems, Lagrange multiplier methods, inequality constraints, Kuhn-
Tucker conditions, and applications. Also considered are the linear and
nonlinear inverse problems, regularization of ill-posed problem including
singular value decomposition and Tikhonov regularization methods,
inverse eigenvalue problems, and applications. Prerequisites: MATH 307,
MATH 312 and MATH 316.

BDA 450. Senior Project in Big Data Analytics I. 3 Credits.
This course introduces students to practical applications of big data
analytics. Lecture topics include an overview of the various topics in
business, engineering, and government currently using big data analytics.
Students will choose a project involving a real world application to explore
techniques learned during other course work. Course involves written and
oral presentations for students to improve communication and teamwork
skills. Prerequisites: A grade of C or better in STAT 331 and STAT 405.
Pre- or corequisite: BDA 431.

BDA 451. Senior Project in Big Data Analytics II. 3 Credits.
This course allows the student to pursue an in-depth exploration of a project
initiated in BDA 450. The course involves written and oral presentations
for students to improve communication and teamwork skills. Prerequisites:
BDA 450 and permission of instructor.

MATHEMATICAL SCIENCES Courses

MATH 101M. An Introduction to Mathematics for Critical Thinking. 3 Credits.
This course fulfills the math general education requirement for some majors
in the College of Arts and Letters and the College of Education. It can also
be used as a preparation for STAT 130M. An introduction to the ways
in which modern mathematics can be used to analyze the modern world
and make logical decisions. Topics include problem solving, sets, logic,
consumer mathematics (loans, mortgages, annuities), elementary statistics,
chaos and fractals.

MATH 102M. College Algebra. 3 Credits.
A basic course in algebra that emphasizes applications and problem-solving
skills. Topics include finding solutions, graphing of linear equations and
inequalities, graphs and functions, combining polynomials and polynomial
functions, factoring polynomials, simplifying and combining rational
expressions and equations, simplifying roots and radicals, solving radical
equations, and an introduction to quadratic functions and equations. This
course fulfills the math general education requirement and can be used
as a preparation for MATH 162M. MATH 101M is not a prerequisite for
MATH 102M. Not open to students with credit for MATH 162M.

MATH 103M. College Algebra with Supplemental Instruction. 3 Credits.
This course covers the same content as MATH 102M. It is designed for
students who must complete MATH 102M as part of their degree program,
but who do not meet the prerequisites for MATH 102M (Math SAT greater
than 450 and High School GPA of 3.0 or greater). MATH 103M may be
used interchangeably with MATH 102M and may be used as a prerequisite
requirement for any course that requires MATH 102M as a prerequisite.
MATH 103M will require registration for a supplemental instruction session
each week. Prerequisites: Math SAT less than or equal to 450, or, High
School GPA less than 3.0.

MATH 162M. Precalculus I. 3 Credits.
The first course in a two-course sequence designed to provide a strong
preparation for calculus. Topics include algebraic operations, equations
and inequalities, graphs and functions, polynomial functions, theory of
equations, systems of equations, exponential functions, and logarithmic
functions. Prerequisite: qualifying score on SAT or ACT, or qualifying score
on a placement test administered by the University Testing Center or a grade
of C or better in MATH 102M or MATH 103M.

MATH 163. Precalculus II. 3 Credits.
The second course in a two-course sequence designed to provide strong
preparation for calculus. Topics include exponential and logarithmic
functions/equations, trigonometric functions/equations, trigonometric
identities, laws of sines and cosines, vectors, polar representation of complex
numbers, binomial theorem, and conic sections. Prerequisite: A grade of C
or better in MATH 162M.

MATH 166. Precalculus I and II. 4 Credits.
A one-semester precalculus course covering the topics of MATH 162M
and MATH 163 at an accelerated pace. Not available to students with credit
in MATH 163. Prerequisites: A grade of C or better in MATH 102M or
MATH 103M.

MATH 200. Calculus for Business and Economics. 3 Credits.
The derivative and optimization, exponential functions and growth, and
integration with applications to future value and consumer’s and producer’s
supply. Prerequisites: A grade of C or better in MATH 162M.

MATH 205. Calculus for Life Sciences. 3 Credits.
This course covers the standard topics of first semester calculus including
limits, derivatives and integrals. All examples for this course are drawn from
biological sciences with specific applications to topics covered in the core
courses of the undergraduate Biology major. Prerequisite: A grade of C or
better in MATH 162M.

MATH 211. Calculus I. 4 Credits.
A first course in calculus and analytic geometry. Topics include
differentiation and integration of algebraic and transcendental functions
of one variable and applications. Prerequisites: A grade of C or better
in MATH 163 or MATH 166.

MATH 212. Calculus II. 4 Credits.
A second course in calculus and analytic geometry. Topics include
techniques of integration, polar coordinates, infinite series, solid geometry,
Vectors, lines and planes. Prerequisite: A grade of C or better in MATH 211.

MATH 280. Transfer Credit for Ordinary Differential Equations. 3 Credits.
This course is a VCCS transfer credit vehicle. Students who have earned
transferable credit in MATH 279 or 291 at any member institution of the
VCCS will be granted credit for MATH 280. The course will not be offered
for credit by Old Dominion University. Cannot be used to substitute for
MATH 307 for MATH majors or minors.

MATH 285. Transfer Credit for Calculus III. 4 Credits.
This course is a VCCS transfer credit vehicle. Students who have earned
transferable credit for MATH 275 or 277 at any member institution of the
VCCS will be granted credit for MATH 285. The course will not be offered
for credit by Old Dominion University. Cannot be used to substitute for
MATH 312 for MATH majors or minors.

MATH 295. Topics in Mathematics. 1-5 Credits.
Study of selected topics. Prerequisite: departmental permission.
MATH 300. Number Systems. 3 Credits.
Sets and systems of numbers, prime, integer, rational, irrational, real, complex and their properties. Representation of numbers. Divisibility, congruence, modular arithmetic, elementary number theory and symbolic logic. (May not be used to satisfy the upper-division elective requirement of the math majors program.) Prerequisite: A grade of C or better in MATH 102M or MATH 103M or MATH 162M.

MATH 302. Geometry. 3 Credits.
Elementary plane and solid Euclidean geometry with proofs and applications. Topics include angles, triangles, congruence, quadrilaterals, circles, similarity, perimeter, area, volume, polygons, plane and solid constructions. A dynamic geometry visualization software is used to discover geometric properties. (May not be used to satisfy the upper-division elective requirement of the math majors program.) Prerequisite: A grade of C or better in MATH 102M or MATH 103M or MATH 162M.

MATH 305. Discrete Math. 3 Credits.
Topics: Vectors and matrices, linear programming, operations on sets, combinatorics, permutations, combinations, elementary probability, logic, relations and functions, induction, graphs and trees, applications. (May not be used to satisfy the upper-division elective requirement of the math majors program.) Prerequisite: A grade of C or better in MATH 102M or MATH 103M or MATH 162M.

MATH 307. Ordinary Differential Equations. 3 Credits.
Topics include first order differential equations and systems, second and higher order linear equations, solution by series and Laplace transform, and applications. Prerequisite: A grade of C or better in MATH 212.

MATH 311W. Abstract Algebra. 3 Credits.
Topics include introduction to logic and methods of proof; sets, relations, and functions; elementary group and ring theory. (This is a writing intensive course.) Prerequisite: A grade of C or better in ENGL 211C or ENGL 221C or ENGL 231C; MATH 212 or departmental permission.

MATH 312. Calculus III. 4 Credits.
A third course in calculus and analytic geometry. Topics include vector functions, partial derivatives, multiple integrals and an introduction to vector calculus. Prerequisite: A grade of C or better in MATH 212.

MATH 316. Introductory Linear Algebra. 3 Credits.
An introduction to linear algebra. Topics include matrices, vectors, vector spaces, linear transformations, eigenvalues and eigenvectors. Prerequisites: A grade of C or better in MATH 212.

MATH 317. Calculus IV: Introductory Analysis. 3 Credits.
An introduction to real analysis. Topics covered include completeness and topological properties of real line, theory of sequences, limits of functions, continuity, Fundamental Theorem of calculus, Leibniz’s rule. Prerequisites: A grade of C or better in MATH 212.

MATH 335. Number Systems and Discrete Mathematics. 3 Credits.
Estimation and other applications to real world problems, using elementary principles of algebra, geometry, number theory, number systems, and discrete mathematics. (May not be used to satisfy the upper-division elective requirement of the math majors program.) Prerequisite: A grade of C or better in MATH 102M or MATH 103M or MATH 162M.

MATH 367. Cooperative Education. 1-3 Credits.
Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work experience is to take place. Available for pass/fail grading only. May be repeated for credit. (qualifies as a CAP experience) Prerequisite: approval by the department and Career Development Services in accordance with the policy for granting credit for Cooperative Education programs.

MATH 375. Advanced Concepts for Secondary Educators: Function and Modeling. 3 Credits.
This course engages students in explorations and laboratory activities designed to strengthen and expand their knowledge of the topics found in college mathematics, and in particular, students will delve into and illuminate the connections between secondary and college mathematics by exploring and highlighting the basic secondary school topics that need to be mastered in order to solve problems in college mathematics. Through this process, students will achieve mastery of topics they will be teaching in secondary mathematics and understand the connection between the high school curriculum and their students’ success in college and in the workplace. Prerequisite: MATH 307.

MATH 395. Topics in Mathematics. 1-3 Credits.
Study of selected topics. Prerequisite: departmental permission.

MATH 400/500. History of Mathematics. 3 Credits.
This course considers some of the major events in the development of mathematics from ancient times through the seventeenth century, including the discovery of incommensurability, the origins of the axiomatic method, trigonometry, solution of equations, calculation of areas and volumes, analytic geometry, probability, and calculus. Students will be graded on tests which consist mostly of problems typical of the periods considered. Prerequisites: A grade of C or better in MATH 212.

MATH 401/501. Partial Differential Equations. 3 Credits.
Not available to students with credit in MATH 691. Separation of variable techniques, Sturm-Liouville systems, generalized Fourier series, orthogonal functions of the trigonometric, Legendre and Bessel type boundary value problems associated with the wave equation and the heat conduction equation in various coordinate systems, applications to physics and engineering. Prerequisites: A grade of C or better in MATH 307 and MATH 312.

MATH 404/504. Fundamental Concepts of Geometry. 3 Credits.
Fundamentals of Euclidean and non-Euclidean geometry. Alternatives to Euclidean geometry are examined using a variety of mathematical techniques. Special topics such as “Taxicab” geometry, the hyperbolic plane, the art of M.C. Escher, and the mathematics of maps may be included. Prerequisites: MATH 311W.

MATH 406/506. Number Theory and Discrete Mathematics. 3 Credits.
A survey course. Topics include the prime number theorem, congruences, Diophantine equations, continued fractions, quadratic reciprocity, combinatorics, logic, graphs, trees, algorithms, coding and linear programming. Prerequisites: MATH 311W and MATH 316.

MATH 408/508. Applied Numerical Methods I. 3 Credits.
An introduction to the numerical methods commonly used by scientists and engineers. Topics include solutions of equations of one variable, direct methods for solving linear systems, matrix factorization, stability analysis, iterative techniques, polynomial interpolation, numerical differentiation and integration, approximation theory, and initial and boundary value problems for ordinary differential equations. Prerequisites: A grade of C or better in MATH 316; CS 150 or equivalent programming ability also required.

MATH 409/509. Applied Numerical Methods II. 3 Credits.
Topics include least squares problems, the QR factorization, the conjugate gradient method, Housholder transformation and the QR method for approximating eigenvalues and singular values of a matrix. For applications, the finite difference method and the finite element method for solving partial differential equations, trigonometric interpolation and FFT as well as introductory study of optimization are discussed. Prerequisites: A grade of C or better in MATH 408/MATH 508.
MATH 496/596. Ordinary Differential Equations. 3 Credits.
A rigorous course in classical real analysis. Topics include the topology of Euclidean n-space, properties of vector valued functions of several variables such as limits, continuity, differentiability and integrability, pointwise and uniform convergence of sequences and series of functions; Fourier series. Prerequisite: a grade of C or better in MATH 317.

MATH 417/517. Intermediate Real Analysis I. 3 Credits.
A rigorous course in classical real analysis. Topics include the topology of Euclidean n-space, properties of vector valued functions of several variables such as limits, continuity, differentiability and integrability, pointwise and uniform convergence of sequences and series of functions; Fourier series. Prerequisite: a grade of C or better in MATH 317.

MATH 418/518. Intermediate Real Analysis II. 3 Credits.
A rigorous course in classical real analysis. Topics include the topology of Euclidean n-space, properties of vector valued functions of several variables such as limits, continuity, differentiability and integrability, pointwise and uniform convergence of sequences and series of functions; Fourier series. Prerequisite: A grade of C or better in MATH 417.

MATH 420/520. Applied Mathematics I: Biomathematics. 3 Credits.
An introduction to current developments in the mathematical investigation of biological problems. Topics include scaling systems of differential equations, stability, perturbation methods, bifurcation phenomena and wave propagation. Applications are chosen from interacting populations, transport and reaction diffusion kinetics, transmission of nerve impulses, and cardiovascular modeling. Prerequisite: A grade of C or better in MATH 307.

MATH 421/521. Applied Mathematics II: Mathematical Modeling. 3 Credits.
A one semester course in formulating, evaluating and validating mathematical models of physical phenomena. Models of traffic flow, mechanical vibrations, combustion, quantum mechanics, wave propagation or other fields of applied mathematics will be examined. Techniques learned in previous courses are used to simplify, analyze and solve these models. New methods introduced include phase-plane analysis, characteristics, calculus of variations and perturbation methods. Prerequisites: A grade of C or better in MATH 307, MATH 312, MATH 316, and MATH 317.

MATH 422/522. Applied Complex Variables. 3 Credits.
Not available to students with credit in MATH 692. Topics include complex numbers, analytical functions and their properties, derivatives, integrals, series representations, residues and conformal mappings. Applications of the calculus of residues and mapping techniques to the solution of boundary value problems in physics and engineering. Prerequisite: A grade of C or better in MATH 312.

MATH 427/527. Applied Mathematics III: Elasticity. 3 Credits.
An introduction to the mathematical theory of linear and non-linear elastic continua. Topics include vectors, tensors, deformation, stress, nonlinear constitutive theory, exact solutions, infinitesimal theory, antiplane strain, plane strain, plane stress, extension, torsion, bending and elastic wave propagation. Prerequisites: A grade of C or better in MATH 307 and MATH 312.

MATH 428/528. Applied Mathematics IV: Fluid Mechanics. 3 Credits.
A mathematical investigation of the differential equations governing fluid flow with an emphasis on steady state incompressible flows. The Navier-Stokes equations are derived and some exact solutions are presented including the potential flow solutions. Topics therefore include classical ideal fluid flow and its complex variable representation, various approximations to the Navier-Stokes equations, boundary layer theory, and also surface and internal gravity wave motion, aspects of hydrodynamic stability theory and convection. Other topics may be introduced by the instructor. Corequisite: MATH 401. Prerequisites: A grade of C or better in MATH 307 and MATH 312.

MATH 457/557. Mathematics in Nature. 3 Credits.
A calculus and differential equations based description of many patterns observable in the natural world including wave motion in the air, oceans, rivers, and puddles; rainbows, halos and other meteorological phenomena; arrangement of leaves, petals and branches; height of trees; river meanders; animal and insect markings; mudcracks; spider webs; and others. Partial differential equations will be discussed as needed but a knowledge of ordinary differential equations will be assumed. Prerequisite: A grade of C or better in MATH 307.

MATH 496/596. Topics in Mathematics. 1-3 Credits.
Study of selected topics. Prerequisite: permission of the instructor.
STAT 435/535. Design and Analysis of Experiments. 3 Credits.
Topics include analysis of variance with one or more factors, multiple comparisons, randomized blocks, Latin squares and related designs: multifactor factorial experiments; blocking and confounding in the 2(k) factorial design; two-level fractional factorial designs. Statistical software will be used to analyze real life data. Prerequisites: A grade of C or better in STAT 405 or STAT 505 and STAT 437 or STAT 537.

STAT 437/537. Applied Regression and Time Series Analysis. 3 Credits.
Topics include theory of least squares, simple linear regression, multiple regression and residual analysis. Multicollinearity issues, regression on dummy variables, extensions to dependent errors and introduction to elementary time series, including auto-regressive and moving-average models will also be discussed. Fitting and interpreting the models using SAS and R software for real data is emphasized. Prerequisites: A grade of C or better in STAT 330 or STAT 310 or STAT 431/STAT 531. Pre- or corequisites: STAT 405/STAT 505.

STAT 440/540. Clinical Trials. 3 Credits.
An introduction to statistical methods used in the design, conduct, and analysis of clinical trials. Topics include: study designs, treatment allocation, sample size and power, clinical life tables, log rank test, cross-over designs, and sequential methods of monitoring clinical trials. Prerequisites: A grade of C or better in STAT 431/STAT 531.

STAT 442/542. Environmental Statistics. 3 Credits.
Topics include nonlinear and generalized linear models, quantitative risk assessment, analysis of stimulus-response and spatially correlated data, methods of combining data from several independent studies. Regression settings are emphasized where one or more predictor variables are used to make inferences on an outcome variable of interest. Applications include modeling growth inhibition of organisms exposed to environmental toxins, spatial associations of like species, risk estimation, and spatial prediction. SAS is used extensively in the course. Prerequisites: A grade of C or better in STAT 431/STAT 531 or permission of the instructor; STAT 437 or STAT 537 recommended.

STAT 447/547. Analysis of Longitudinal Data. 3 Credits.
Topics include general linear models, weighted least squares (WLS), maximum likelihood (ML), restricted maximum likelihood (REML) methods of estimation, analysis of continuous response repeated measures data, parametric models for covariance structure, generalized estimating equations (GEE) and quasi least squares (QLS), models for discrete longitudinal data: marginal, random effects, and transition models. Limitations of existing approaches will be discussed. Emphasis will be on the application of these tools to data related to the biological and health sciences. Methods will be implemented using statistical software. Prerequisites: A grade of C or better in STAT 431/STAT 531 or permission of the instructor; STAT 437 or STAT 537 recommended.

STAT 449/549. Nonparametric Statistics. 3 Credits.
Topics include the theory and applications of binomial tests and rank tests, including the tests of McNemar, Mann-Whitney, Friedman, Kruskal-Wallis, and Smirnov. Prerequisites: A grade of C or better in STAT 330 or STAT 310 or STAT 431/STAT 531. Pre- or corequisite: STAT 405/STAT 505.

STAT 450/550. Categorical Data Analysis. 3 Credits.
Topics include relative risk and odds ratio measures for 2 x 2 tables, the chi-square and Mantel-Haenszel tests, Fisher's exact test, analysis of sets of 2 x 2 tables using Cochran-Mantel-Haenszel methodology, analysis of I x J and sets of I x J tables for both nominal and ordinal data, logistic regression including the logit and probit models, and building and applying loglinear models. Emphasis will be on the application of these statistical tools to data related to the health and social sciences. Interpretation of computer output will be stressed. Prerequisites: A grade of C or better in STAT 431/STAT 531. Pre- or corequisite: STAT 405/STAT 505.

STAT 460/560. Statistical Simulation/Programming Using Statistical Software Packages. 3 Credits.
This course is a data-based tour of advanced statistical techniques using software packages, exploring a catalog of data sets (simulated or otherwise) spanning a variety of fields and applications, including data suitable for regression, ANOVA, time series modeling, longitudinal data analysis, and multivariate techniques. Approaches will include parametric, nonparametric, simulation, and bootstrapping. SAS and R (S-plus) will be used extensively, with some other specialized products. For writing actual (not packaged) code, PROC IML and R will be used. This is a finishing course for applied statisticians, highly recommended for students planning a career in statistical programming and simulation. Prerequisites: A grade of C or better in STAT 405/505 and two of STAT 435/STAT 535, STAT 437/STAT 537, STAT 447/STAT 547 and STAT 450/STAT 550.

STAT 497/597. Topics in Statistics. 1-3 Credits.
The advanced study of selected topics. Prerequisites: permission of the instructor.