Mathematics and Statistics

Web Site: http://www.odu.edu/math

Gordon Melrose, Chair
Robert Strozak, Chief Departmental Advisor

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 science, 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. A double major within the Department of Mathematics and Statistics will not satisfy the University’s upper-division general education requirement under Option B except for a double major in applied mathematics and statistics/biostatistics. The requirements of each major along with the professional education courses needed for teacher licensure in the Commonwealth of Virginia are listed below. All students earning a Bachelor of Science in Mathematics have to successfully complete the mathematics core course requirements.

Requirements

Lower-Division General Education

<table>
<thead>
<tr>
<th>Composition</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral Communication</td>
<td>3</td>
</tr>
<tr>
<td>Mathematics (met in the major by MATH 211)</td>
<td>0-6</td>
</tr>
<tr>
<td>Language and Culture</td>
<td>3</td>
</tr>
<tr>
<td>Information Literacy and Research</td>
<td>3</td>
</tr>
<tr>
<td>CS 121G Introduction to Information Literacy and Research for Scientists (preferred)</td>
<td>3</td>
</tr>
<tr>
<td>Human Creativity</td>
<td>3</td>
</tr>
<tr>
<td>Interpreting the Past</td>
<td>3</td>
</tr>
<tr>
<td>Literature</td>
<td>3</td>
</tr>
<tr>
<td>Human Behavior</td>
<td>3</td>
</tr>
<tr>
<td>Philosophy and Ethics (PHIL 120P recommended)</td>
<td>3</td>
</tr>
<tr>
<td>The Nature of Science</td>
<td>8</td>
</tr>
<tr>
<td>Impact of Technology</td>
<td>3</td>
</tr>
<tr>
<td>Total Hours</td>
<td>38-44</td>
</tr>
</tbody>
</table>

* 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.

Mathematics Core Course Requirements

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<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>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>3</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.

Other Required courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</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 200</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</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>
</tbody>
</table>

Total Hours: 18

Major in Applied Mathematics

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 200</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</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>
</tbody>
</table>

Total Hours: 18

Major in Statistics/Biostatistics

<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>3</td>
</tr>
<tr>
<td>STAT 405</td>
<td>Introduction to Data Handling</td>
<td>3</td>
</tr>
<tr>
<td>STAT 400</td>
<td>400-level electives (or approved BDA courses)</td>
<td>12</td>
</tr>
</tbody>
</table>

Total Hours: 18

Major in Actuarial Mathematics

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 described in this Catalog. Students are encouraged to obtain revision. Any changes resulting from these factors supersede the program preparation programs in the College of Sciences are under constant and the Virginia Board of Education licensure regulations, the teacher Due to changing University requirements, national accreditation standards, Bachelor of Science in Mathematics with this degree. credit hours for all students earning a B.S. in Mathematics. 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. Four-Year Plan - Mathematics Major - BS (http://catalog.odu.edu/undergraduate/ collegeofsciences/mathematicssstatistics/ mathematics-bs-fouryearplan/) This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree. Bachelor of Science in Mathematics with Teaching Licensure Due to changing University requirements, national accreditation standards, and the Virginia Board of Education licensure regulations, the teacher preparation programs in the College of Sciences are under constant revision. Any changes resulting from these factors supersede the program requirements described in this Catalog. Students are encouraged to obtain current program information from their advisors and the Office of Clinical Experiences website at www.odu.edu/oce (http://www.odu.edu/oce/).

Admission
Students must first declare mathematics with teaching licensure as their program with the mathematics departmental advisor. All students must apply for and be admitted into the approved mathematics teacher preparation program. Students must meet the required criteria for admission by passing the Virginia Board of Education prescribed assessments and earn the minimum required grade point averages (GPA).

Virginia Board of Education Prescribed Assessments for Admission to an Approved Teacher Education Program
Old Dominion University students seeking admission to an approved teacher education program must have submitted Praxis Core or approved alternative test of mathematics, reading, and writing (SAT or ACT).

For the most current information on the prescribed Virginia Board of Education admission assessment, visit the Office of Clinical Experiences website, http://www.odu.edu/oke (http://www.odu.edu/oke/) and review the Professional Education Handbook.

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 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 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. 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 continuation 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 (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 for Licensure**

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 Office of Clinical Experiences website, www.odu.edu/once (http://www.odu.edu/once/).

**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.

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>or MATH 422</td>
<td>Applied Complex Variables</td>
<td></td>
</tr>
<tr>
<td>MATH 400-level electives (or approved BDA courses)</td>
<td>6</td>
<td></td>
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</tbody>
</table>

**Total Hours** 21

**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>
<tr>
<td>STEM 102</td>
<td>Step 2 - Inquiry Based STEM Lesson Design</td>
<td>1</td>
</tr>
<tr>
<td>STEM 201</td>
<td>Knowing and Learning in STEM Education</td>
<td>3</td>
</tr>
<tr>
<td>STEM 202</td>
<td>Classroom Interactions in STEM Education</td>
<td>3</td>
</tr>
<tr>
<td>STEM 401</td>
<td>Project Based Instruction in STEM Education</td>
<td>3</td>
</tr>
<tr>
<td>STEM 402</td>
<td>Perspectives on STEM</td>
<td>3</td>
</tr>
<tr>
<td>STEM 485</td>
<td>Apprentice Teaching</td>
<td>9</td>
</tr>
<tr>
<td>SCI 468</td>
<td>Research Methods in Math and Sciences</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>(Satisfied by BIOL 468W, CHEM 468, OEAS 468W, or PHYS 468W)</td>
<td></td>
</tr>
</tbody>
</table>

**Total Hours** 26

**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, completion of ENGL 110C and ENGL 211C or ENGL 221C or ENGL 231C with a grade of C or better, and completion of the Senior Assessment.

**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.

**Four-Year Plan - Mathematics with Teaching Licensure - BS** (http://catalog.odu.edu/undergraduate/collegeofsciences/mathematicsstatistics/mathematics-mathed-bs-fouryearplan/)

This is a suggested curriculum plan to complete this degree program in four years. Please consult information in this Catalog, Degree Works, and your academic advisor for more specific information on course requirements for this degree.

**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>
<tr>
<td>MATH 420</td>
<td>Applied Mathematics I: Biomathematics</td>
<td></td>
</tr>
<tr>
<td>MATH 421</td>
<td>Applied Mathematics II: Mathematical Modeling</td>
<td></td>
</tr>
<tr>
<td>MATH 422</td>
<td>Applied Complex Variables</td>
<td></td>
</tr>
<tr>
<td>MATH 427</td>
<td>Applied Mathematics III: Elasticity</td>
<td></td>
</tr>
</tbody>
</table>
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 credits of graduate courses toward both their undergraduate and master's degrees. Students in the program may substitute mathematics or statistics courses for prerequisite courses.

Advanced Placement

Advanced placement credit is awarded to students who earn qualifying scores on AP and IB subject examinations. See the equivalency charts on the Office of Undergraduate Admissions website at https://www.odu.edu/admission/undergraduate/credit (https://www.odu.edu/admission/undergraduate/credit). 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, but credit may be awarded with a qualifying IB score.

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 discrete credit hours for the undergraduate degree and 30 discrete credit hours 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.

## BIG DATA ANALYTICS Courses

**BDA 401/501. Programming Languages for Data Science. 3 Credits.**

An introductory course on programming languages and tools which are relevant to data analytics. Each language or tool is introduced as a separate module and incorporates applications in mathematics and statistics. Examples of included programming languages and tools are MATLAB, Python, R and SAS. Additional languages and tools may be covered based on current trends in data analytics. Students will complete hands-on programming assignments throughout the course. Prerequisites: MATH 312, MATH 316 and STAT 330 or STAT 331.

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

An introductory course on machine learning. Machine Learning is the science of discovering pattern and structure and making predictions in data sets. It lies at the interface of mathematics, statistics and computer science. The course gives an elementary summary of modern machine learning tools. Topics include regression, classification, regularization, resampling methods, and unsupervised learning. 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 330 or STAT 331.
BDA 431/531. Modern Statistical Methods for Big Data Analytics. 3 Credits.
The statistical perspective of data mining is emphasized for 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 include Regularization and Kernel Smoothing Methods, Tree-based Methods, Neural Networks and optional topics such as deep learning. Prerequisites: BDA 411 and STAT 405.

BDA 432/532. Introduction to Optimization and Inverse Problems. 3 Credits.
Topics considered include the solution of non-smooth optimization problems arising in data science, including unconstrained and constrained optimization problems, Lagrange multiplier methods, inequality constraints, Kuhn-Tucker conditions, and applications. Also considered are linear and nonlinear inverse problems, regularization of ill-posed problem including singular value decomposition, and Tikhonov regularization methods and sparse regularization methods, inverse eigenvalue problems and applications such as compressed sensing, image reconstruction and machine learning. 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 100. The Math Cooperative. 0 Credits.
This course provides support and preparation in math for students who suffer from math anxiety, have math SAT scores of 450 or below or have not taken a math course in over a year. The goal of this course is to build students' confidence in their math abilities in order to help them be successful in math.

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 and Professional Studies. 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), probability, and elementary statistics.

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. Prerequisite: High School GPA of 3.0 or higher and SAT score of 540 and above or qualifying score on a placement test administered by the University Testing Center.

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 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.

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 surplus. 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 include 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. Prerequisites: 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. 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 399. Putnam Exam Problems and Related Topics. 1 Credit.
This course is designed to help students prepare for the Putnam Exam - an annual national mathematical competition. Problems from previous Putnam Exams and materials related to the solution of such problems will be considered. Prerequisites: A grade of C or better in MATH 212.

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: MATH 311W or MATH 316 or MATH 317.

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, Householder 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 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 461. Preparation for Praxis Certification. 3 Credits.
This course will equip students to pass the Praxis 5161 Mathematics: Content Knowledge Exam. This exam is required for teaching licensure at the secondary level in Virginia. Only open to students in the Secondary School Teaching Option in the Math B.S. program who have not yet passed the Praxis 5161 Exam. Prerequisites: Instructor approval.

MATH 494. Entrepreneurship in Mathematics. 3 Credits.
This course is designed to help students enhance their personal and professional development through innovation guided by faculty members and professionals. It offers students an opportunity to apply their knowledge of mathematics to the development of a new product, business, nonprofit program, or other initiative. The real world experiences that entrepreneurship provides will help students understand how academic knowledge leads to transformations, innovations, and solutions to different types of problems. This course is administered as an independent project for individual students, or as group projects. Prerequisites: 3.0 GPA and permission of the chief departmental advisor.

MATH 496/596. Topics in Mathematics. 1-3 Credits.
Study of selected topics. Prerequisite: permission of the instructor.

MATH 498/598. Tutorial Work in Special Topics in Mathematics. 1-3 Credits.
Independent study under the direction of an instructor including library research and reports. Prerequisite: permission of the instructor.
STAT 405/505. Introduction to Data Handling, 3 Credits.
Use of SAS and R to handle data sets. Topics for SAS include data input, creating permanent data sets, merging data sets, creating new variables, sorting, printing, charting, formatting, IML programming, and an overview of proc SQL and other statistical procedures. Topics for R include data structure, control structure, writing functions, and graphics. Prerequisites: grade of C or better in STAT 130M or equivalent and a grade of C or better in MATH 316 or equivalent or permission of instructor.

STAT 431/531. Theory of Statistics, 3 Credits.
Topics include point and interval estimation, tests of hypotheses, introduction to linear models, likelihood techniques, and regression and correlation analysis. Prerequisites: A grade of C or better in STAT 331 or departmental permission.

STAT 432/532. Sampling Theory, 3 Credits.
Sampling from finite populations is discussed. Topics such as simple random sampling, stratified random sampling and ratio and regression estimation are included. Also discussed are aspects of systematic sampling, cluster sampling, and multi-stage sampling. Prerequisites: A grade of C or better in STAT 431/STAT 531.

STAT 435/535. Design and Analysis of Experiments, 3 Credits.
Topics include introduction to design of experiments, analysis of variance with a single factor, power and OC curves, and two factors with interactions, random effects models, randomized blocks, Latin square and related designs, introduction to factorial and 2k factorial designs. Statistical software will be used to analyze real life data. Prerequisites: STAT 431/STAT 531 or STAT 437/STAT 537. Pre- or corequisite: STAT 405/STAT 505.

STAT 437/537. Applied Regression and Time Series Analysis, 3 Credits.
Topics include introduction to regression and model building, simple linear regression, multiple regression, logistic regression, and simple time series, residual analysis, selection of variables, model adequacy checking, regression on dummy variables, analysis of covariance, regression analysis of time series data, and applications of these techniques to real life data using statistical software. 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.
This course will introduce basic statistical concepts and methods used in clinical trials. Topics include trial designs, including parallel, group allocation, cross-over, and factorial designs; randomization; sample size and power calculation; survival analysis; and monitoring of trials for safety and efficacy. 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.
This course introduces statistical methods for analyzing multivariate and longitudinal data. Topics include multivariate normal distribution, covariance modeling, multivariate linear models, principal components, analysis of continuous response repeated measures, and models for discrete longitudinal data. Emphasis will be on the applications to the biological and health sciences and the use of the statistical software. Prerequisites: A grade of C or better in STAT 431/STAT 531. Pre- or corequisite: STAT 405/STAT 505.

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 331 or departmental permission.

STAT 450/550. Categorical Data Analysis, 3 Credits.
Topics include types of categorical data, 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. 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/STAT 505 and two of STAT 435/STAT 535, STAT 437/STAT 537, STAT 447/STAT 547 and STAT 450/STAT 550.

STAT 494. Entrepreneurship in Statistics, 3 Credits.
This course is designed to help students enhance their personal and professional development through innovation guided by faculty members and professionals. It offers students an opportunity to apply their knowledge of statistics to the development of a new product, business, nonprofit program, or other initiative. The real world experiences that entrepreneurship provide will help students understand how academic knowledge leads to transformations, innovations, and solutions to different types of problems. This course is administered as an independent project for individual students, or as group projects. Prerequisites: 3.0 GPA and permission of the chief departmental advisor.

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