Department of Mathematics

Chair: Dr. Milena Stanislavova

The Department of Mathematics offers courses in pure and applied mathematics and a major and minor in mathematics leading to employment in education, government, business, and industry. In addition, mathematics courses are offered to support programs in the physical, social, biological, and health sciences and in engineering, business, and education. Students considering a major or minor in mathematics should consult the undergraduate advisor, Dr. Hutchison, at (205) 934-2154 to arrange for counseling on career and academic objectives and program planning.

The Department of Mathematics Web site (https://www.uab.edu/cas/mathematics/) summarizes information about the Departmental programs.

For the major there are four distinct B.S. degree tracks in mathematics:

1. Mathematics (traditional track)
2. Mathematics with Honors
3. Applied Mathematics and Scientific Computation
4. Mathematical Reasoning

Students interested in secondary teaching certification in mathematics normally take the traditional track. Students interested in middle school teaching normally take the mathematical reasoning track. Certification courses are part of the UABTeach program.

Mathematics Fast-Track Program

The Department of Mathematics has an accelerated program for qualified students. Through this Fast-Track option, a mathematics major can earn a BS degree and an MS degree in mathematics in four to five years (depending upon whether summer terms are included). As another option, students can pursue a BS in mathematics and an MS in biostatistics by choosing the biostatistics track at the end of the third year. Each individual Fast-Track student works with a mentor from the graduate faculty on a mathematics research project during every term. Fast-Track students will usually begin taking graduate mathematics courses after the third year, and are automatically admitted to the graduate program in the fourth year, if performing satisfactorily. Students who complete this program will be prepared for continued graduate work in mathematics and the sciences, or for careers in industry. Fast-Track scholarships are available. For more information, contact the Honors Program Director, Dr. Oversteegen, at (205) 934-2154.

Course Numbering System

Mathematics course numbers indicate both the level and area of the course. The first digit (0, 1, 2, 3, or 4) indicates developmental (no degree credit), freshman, sophomore, junior, or senior level, respectively. The second and third digits indicate area, according to this scheme:

• 00–10 — Pre-calculus
• 11–19 — History of mathematics and mathematical reasoning
• 20–29 — Logic and foundations
• 30–39 — Algebra
• 40–49 — Analysis
• 50–59 — Differential equations
• 60–69 — Applications-oriented courses
• 70–79 — Geometry and topology
• 80–89 — Probability and statistics
• 90–99 — Special topics, seminars, and independent research

For example, MA 454 Intermediate Differential Equations is an advanced level differential equations course. Calculus courses (MA 125, MA 225, MA 126, MA 226 and MA 227) are exceptions to the area numbering scheme.

Graduate Programs

The Department of Mathematics offers graduate study leading to the degrees of Master of Science in mathematics (thesis or non-thesis option) and Doctor of Philosophy in applied mathematics. Further information may be obtained from the Graduate Program Director, or the UAB Graduate School Catalog.

See the UAB Graduate School Catalog for descriptions of graduate courses.

Bachelor of Science with a Major in Mathematics

Requirements

<table>
<thead>
<tr>
<th>Required Mathematics Courses</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thirty-nine semester hours with twenty-one at the 300 level or above</td>
<td></td>
</tr>
<tr>
<td>MA 125 Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>or MA 225 Calculus I - Honors</td>
<td></td>
</tr>
<tr>
<td>MA 126 Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>or MA 226 Calculus II - Honors</td>
<td></td>
</tr>
<tr>
<td>MA 227 Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MA 252 Introduction to Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MA 260 Introduction to Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>or MA 434 Algebra I: Linear</td>
<td></td>
</tr>
<tr>
<td>MA 440 Advanced Calculus I</td>
<td>3</td>
</tr>
<tr>
<td>MA 441 Advanced Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>Select one of the following:</td>
<td>3</td>
</tr>
<tr>
<td>MA 360 Scientific Programming</td>
<td></td>
</tr>
<tr>
<td>CS 380 Matrix Computation</td>
<td></td>
</tr>
<tr>
<td>MA 361 Mathematical Modeling</td>
<td></td>
</tr>
<tr>
<td>MA 461 Modeling with Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MA 468 Numerical Analysis I</td>
<td></td>
</tr>
</tbody>
</table>

Mathematics Electives and Advanced Mathematics Sequence 12

Four electives selected from courses numbered 300 or above, each of which must have at least a calculus (MA 125) prerequisite. MA 313 counts toward the major only for students in UABTeach. MA 411 or MA 480 does not count toward the major.

Choose one of the following Advanced Mathematics sequences as electives:

<table>
<thead>
<tr>
<th>Mathematics Electives</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 434 Algebra I: Linear</td>
<td></td>
</tr>
<tr>
<td>&amp; MA 435 and Algebra II: Modern</td>
<td></td>
</tr>
<tr>
<td>MA 454 Intermediate Differential Equations</td>
<td></td>
</tr>
<tr>
<td>&amp; MA 455 and Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MA 455 Partial Differential Equations I</td>
<td></td>
</tr>
<tr>
<td>&amp; MA 461 and Modeling with Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>MA 474 Introduction to Topology I</td>
<td></td>
</tr>
<tr>
<td>&amp; MA 475 and Introduction to Topology II</td>
<td></td>
</tr>
</tbody>
</table>

1. Mathematics courses numbered 100 or above may count toward the major, but not the General Electives (GE) requirement (12 hours credit).

2. Mathematics courses numbered 100 or above may count toward the major, but not the General Electives (GE) requirement (12 hours credit).

3. Mathematics courses numbered 100 or above may count toward the major, but not the General Electives (GE) requirement (12 hours credit).

4. Mathematics courses numbered 100 or above may count toward the major, but not the General Electives (GE) requirement (12 hours credit).
A mathematical model is a rendering of some real-world system into the language of mathematics, usually taking the form of a single partial differential equation, or a system of such equations. The development of effective mathematical models is a fundamental need of our society, based as it is upon science and technology, and these models act as the indispensable link between us humans and the multitude of machines that we use to manage and investigate our world.

**Grade Requirement**
A grade of C or better is required in each course counted toward the major.

**Minor**
- A minor is required for this degree. Those interested in secondary education can select the STEM Education minor offered by the School of Education.

**General Electives**
Students must take general electives to reach the 120 semester hour requirement.

**Bachelor of Science with a Major in Mathematics and an Applied Mathematics and Scientific Computation Track**
This track aims to provide graduates with the mathematical and computational skills needed to develop and maintain mathematical models from the Sciences, Engineering, Medicine and the Biosciences, Business, and elsewhere.

A mathematical model is a rendering of some real-world system into the language of mathematics, usually taking the form of a single partial differential equation, or a system of such equations. The development of effective mathematical models is a fundamental need of our society, based as it is upon science and technology, and these models act as the indispensable link between us humans and the multitude of machines that we use to manage and investigate our world.

**Requirements**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 125</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>or MA 225</td>
<td>Calculus I - Honors</td>
<td></td>
</tr>
<tr>
<td>MA 126</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>or MA 226</td>
<td>Calculus II - Honors</td>
<td></td>
</tr>
<tr>
<td>MA 227</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MA 252</td>
<td>Introduction to Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MA 260</td>
<td>Introduction to Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>or MA 434</td>
<td>Algebra I: Linear</td>
<td></td>
</tr>
<tr>
<td>MA 360</td>
<td>Scientific Programming</td>
<td>3</td>
</tr>
<tr>
<td>or CS 380</td>
<td>Matrix Computation</td>
<td></td>
</tr>
<tr>
<td>MA 455</td>
<td>Partial Differential Equations I</td>
<td>3</td>
</tr>
<tr>
<td>or MA 461</td>
<td>Modeling with Partial Differential Equations</td>
<td></td>
</tr>
<tr>
<td>or MA 486</td>
<td>Mathematical Statistics</td>
<td></td>
</tr>
</tbody>
</table>

1 Completion of MA 125 or MA 225 automatically satisfies the Core Curriculum Area III: Math requirement. MA 126 or MA 226, MA 252 and MA 361 are all quantitative literacy (QL) and writing (W) courses. In addition, MA 125 or MA 225 is a QL course. UAB requires that all students complete a capstone requirement. For this track the capstone requirement is MA 441.

**Grade Requirement**
A grade of C or better is required in each course counted toward the major.

**Minor**
- A minor is required for this degree. Those interested in secondary education can select the STEM Education minor offered by the School of Education.

**General Electives**
Students must take general electives to reach the 120 semester hour requirement.

**Bachelor of Science with a Major in Mathematics and a Mathematical Reasoning Track**
The Mathematical Reasoning Track is designed to develop a deeper level of understanding of mathematical thinking, including a deepening knowledge of important mathematical ideas, understanding the role of inquiry and reflection in learning mathematics, understanding the role of cultivating a productive disposition in tackling mathematical problems, and developing the ability to communicate mathematics to audiences at different levels. In particular, this track is appropriate for students interested in pursuing certification in mathematics at the middle school level.
Requirements

Required Mathematics Courses ¹
MA 125 Calculus I 4
or MA 225 Calculus I - Honors
Select two courses from the following three groups: 6-7
MA 106 Pre-Calculus Trigonometry ²
or MA 107 Pre-Calculus Algebra and Trigonometry
MA 110 Finite Mathematics
or MA 418 Statistics for Teachers
MA 126 Calculus II
or MA 226 Calculus II - Honors
Additional Required Mathematics Courses
MA 311 History of Mathematics I 3
MA 313 Patterns, Functions and Algebraic Reasoning 3
MA 314 Geometric and Proportional Reasoning 3
MA 316 Numerical Reasoning 3
MA 361 Mathematical Modeling 3
MA 411 Integrating Mathematical Ideas 3
Mathematics Electives
Two electives selected from the following courses: MA 260 or MA 434, MA 418, MA 419, MA 435, MA 460, MA 472, MA 485 6
Total Hours 34-35

¹ Completion of MA 106 or MA 107 automatically satisfies the Core Curriculum Area III: Math requirement. MA 106, MA 107, MA 110, MA 125 or MA 225, MA 361, MA 418 are all quantitative literacy courses. In addition, MA 361 is a QEP writing (W) course. UAB requires that all students complete a capstone requirement. The capstone requirement for this track is MA 411. At least three courses in this major must be at the 400 level.

² Students cannot count both MA 106 and MA 107 toward their major.

³ MA 419 cannot be repeated for credit toward this major.

Grade Requirements

A grade of C or better is required in each course counted toward the major. Requirements are 34-36 semester hours in mathematics with 24 at the upper level (courses numbered 300 and above). Nine hours must be taken at the 400 level.

Minor

• A minor is required for this degree. Those interested in middle school education can select the STEM Education minor offered by the School of Education.

General Electives

Students must take general electives to reach the 120 semester hour requirement

Proposed Program of Study for a Major in Mathematics with a Traditional Track and Leading to Secondary Teaching Certification

Freshman

First Term | Hours | Second Term | Hours
---|---|---|---
MA 125 | 4 MA 126 | 4 MA 126 | 4
EH 101 | 3 EH 102 | 3 EH 102 | 3
HY 101 | 3 HY 102 | 3 HY 102 | 3
ARH 101 | 3 CS 103 | 3 CS 103 | 3
Total credit hours: 120

Sophomore

First Term | Hours | Second Term | Hours
---|---|---|---
MA 227 | 4 MA 252 | 4 MA 252 | 4
MA 260 | 3 EH 216 | 3 EH 216 | 3
PH 221 | 4 CS 250 | 4 CS 250 | 4
CS 203 | 4 PH 222 | 4 PH 222 | 4
General Elective | | General Elective | 3
Total credit hours: 120

Junior

First Term | Hours | Second Term | Hours
---|---|---|---
MA 260 | 3 MA 435 | 3 MA 435 | 3
MA 472 | 3 MA 486 | 3 MA 486 | 3
MA 485 | 3 EC 210 | 3 EC 210 | 3
CMST 101 | 3 PHL 115 | 3 PHL 115 | 3
EHS 325 | 3 HY 275 or PHL 270 | 3 HY 275 or PHL 270 | 3
PY 101 | | 3 General Electives | 4
General Elective | 9 General Electives | 9
Total credit hours: 120

Proposed Program of Study for a Major in Mathematics with a Traditional Track

Freshman

First Term | Hours | Second Term | Hours
---|---|---|---
MA 125 | 4 MA 126 | 4 MA 126 | 4
EH 101 | 3 EH 102 | 3 EH 102 | 3
HY 101 | 3 HY 102 | 3 HY 102 | 3
ARH 101 | 3 CS 103 | 3 CS 103 | 3
Total credit hours: 120

Sophomore

First Term | Hours | Second Term | Hours
---|---|---|---
MA 227 | 4 MA 252 | 4 MA 252 | 4
MA 260 | 3 EH 216 | 3 EH 216 | 3
PH 221 | 4 CS 250 | 4 CS 250 | 4
CS 203 | 4 PH 222 | 4 PH 222 | 4
General Elective | | General Elective | 3
Total credit hours: 120

Junior

First Term | Hours | Second Term | Hours
---|---|---|---
MA 260 | 3 MA 435 | 3 MA 435 | 3
MA 472 | 3 MA 486 | 3 MA 486 | 3
MA 485 | 3 EC 210 | 3 EC 210 | 3
CMST 101 | 3 PHL 115 | 3 PHL 115 | 3
EHS 325 | 3 Elective | 3 Elective | 4
Total credit hours: 120
### Proposed Program of Study for a Major in Mathematics with an Applied Mathematics and Scientific Computation Track

**Freshman**

<table>
<thead>
<tr>
<th>First Term</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 125</td>
<td>4 MA 126</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>MA 260</td>
<td>3 Core Area II or IV Course</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CS 103</td>
<td>4 Core Area III Science</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Core Area III Science</td>
<td>4 Core EH Literature</td>
<td>CS 203</td>
<td>3</td>
</tr>
<tr>
<td>CAS 112 or EHS 125</td>
<td>1 General Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Total Hours: 14</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Sophomore**

<table>
<thead>
<tr>
<th>First Term</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 227</td>
<td>4 MA 252</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MA 260</td>
<td>3 Core Area II or IV Course</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CS 103</td>
<td>4 Core Area III Science</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>Core Area III Science</td>
<td>4 Core EH Literature</td>
<td>CS 203</td>
<td>3</td>
</tr>
<tr>
<td>Total Hours: 15</td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Junior**

<table>
<thead>
<tr>
<th>First Term</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 360</td>
<td>3 MA 4XX elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MA 4XX Elective</td>
<td>3 MA Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Core Area II or IV Courses</td>
<td>6 CS 303</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CS 250</td>
<td>3 Core Area II or IV Course</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>General Elective</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Total Hours: 15</td>
<td>17</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Senior**

<table>
<thead>
<tr>
<th>First Term</th>
<th>Hours</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 4XX Elective</td>
<td>3 MA 4XX Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>CS 330</td>
<td>3 MA Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>MA Elective</td>
<td>3 General Electives</td>
<td></td>
<td>7</td>
</tr>
<tr>
<td>General Electives</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Total Hours: 15</td>
<td>13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total credit hours: 120

The above schedule assumes the student is in UABTeach and is pursuing middle school certification. If not, EHS courses should be replaced by courses fulfilling requirements for a minor course of study.

### Minor in Mathematics

**Requirements**

<table>
<thead>
<tr>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Hours: 21</td>
</tr>
</tbody>
</table>

**Required Mathematics Courses**

<table>
<thead>
<tr>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 125 Calculus I</td>
</tr>
<tr>
<td>or MA 225 Calculus I - Honors</td>
</tr>
<tr>
<td>MA 126 Calculus II</td>
</tr>
<tr>
<td>or MA 226 Calculus II - Honors</td>
</tr>
<tr>
<td>MA 227 Calculus III</td>
</tr>
</tbody>
</table>

**Mathematics Electives**

Select nine hours from Mathematics courses numbered 200 or above.  

**Total Hours: 21**

1. MA 125 or MA 225 Calculus I may also satisfy the Core Curriculum Area III: Math requirement; check the Core Curriculum for your particular major.
2. At least 6 semester hours of which must have a calculus (MA 125) prerequisite. MA 411 and MA 480 do not count toward the minor.

**GPA & Residency Requirement**

A minimum grade of C is required in all courses applied to the minor. A minimum of six semester hours with a calculus (MA 125) prerequisite must be completed at UAB.
Honors Program

The Mathematics Honors Program is designed for advanced, motivated students. Through a mentored research program format and seminars, research and communication skills are developed in preparation for a graduate or professional career.

The Mathematics Honors Program fosters a spirit of inquiry, independence, and initiative along with providing an overview of the relationships among the branches of mathematics studied. The student will have an early opportunity to tackle a mathematical research project while interacting one-on-one with faculty members in a research setting. The mentoring, the approved seminars, and the oral presentation or poster should all contribute to the student’s development. Upon completion of the program, the student will graduate “With Honors in Mathematics.”

Acceptance into the Mathematics Honors Program requires the student:

- to be a mathematics major in the traditional track;
- to have earned a 3.5 GPA in mathematics courses attempted;
- to have earned a 3.0 GPA overall;
- to have arranged with one or more faculty mentors to work on undergraduate research projects for six semester hours distributed over two or more terms; and
- to have filled out and submitted the Mathematics Honors Program application form to the Undergraduate Program Director.

Major requirements for the Mathematics Honors Program:

- to be a mathematics major in the traditional track;
- to complete an additional 9 hours of approved seminar (3 hours) and research (6 hours);
- to have earned a 3.5 GPA in mathematics courses and a 3.0 GPA overall; and
- to present an oral or poster presentation on mathematics in an academic setting

Suggested Curriculum for the Honors Program:

### Freshman

<table>
<thead>
<tr>
<th>Course</th>
<th>First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 125 or 225</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>MA 101</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MA 102</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>ARH 101</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>FYE/FLC Course</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

### Minor Course

<table>
<thead>
<tr>
<th>Course</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 98</td>
<td>3</td>
</tr>
</tbody>
</table>

### Sophomore

<table>
<thead>
<tr>
<th>Course</th>
<th>First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 298</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>MA 434</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MA 216</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>MA 210</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 298</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>MA 434</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>MA 216</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>MA 210</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

### Junior

<table>
<thead>
<tr>
<th>Course</th>
<th>First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 441</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MA 490</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CS 203</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Course</th>
<th>Second Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 441</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MA 490</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CS 203</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

### Senior

<table>
<thead>
<tr>
<th>Course</th>
<th>First Term</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA 490</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>MA 498</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CS 330</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>General Electives</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

### Total credit hours: 120

Courses

**MA 094. Basic Mathematics. 3 Hours.**
Whole numbers, fractions, decimals, ratios and proportions, percentages, integers, basic geometry, and basic algebra including linear equations and applications. Designed to prepare students for MA 110. Finite Mathematics. Students preparing to take MA 102 should take MA 098. Attendance at the first meeting is mandatory. MA 094 section QL is an on-line version of MA 094 intended primarily for students who have job conflicts or live a long distance from the campus. There are no campus based meetings with the on-line class. However, students in the on-line version of MA 094 are required to interact with peers and the instructor through an on-line format and should be able to work independently and be motivated self-starters who are confident in their ability to master mathematics. Non-credit; does not contribute to any degree requirements. 0.000 Credit Hours.

**MA 094L. Basic Mathematics Lab. 2 Hours.**
This course is a 2 credit hours co-requisite lab designed to supplement the introduction to finite mathematics course MA 108. The lab provides detailed and comprehensive review of whole numbers, fractions, decimals, ratios and proportions, percentages, integers, basic geometry, and basic algebra including linear equations and applications. The emphasis is on hands-on, individualized guidance for mastering the above concepts as well as problem solving and examples of applications in the topics discussed and presented in MA 108.
MA 098. Basic Algebra. 3 Hours.
Arithmetic of integers, rational numbers, real numbers, exponents, polynomial algebra, factoring, rational functions, linear and quadratic equations, elementary geometry, verbal problems. Designed to prepare students for college level math courses. Attendance at the first meeting is mandatory. MA 098 section QL is an on-line version of MA 098 and is intended primarily for students who have job conflicts or live a long distance from the campus. There are no campus based meetings with the on-line class. However, students in the on-line version of MA098 are required to interact with peers and the instructor through an on-line format and should be able to work independently and be motivated self-starters who are confident in their ability to master mathematics. Non-credit; does not contribute to any degree requirements. 0.000 Credit Hours.

MA 102. Intermediate Algebra. 3 Hours.
Absolute values, Cartesian coordinates, graphs of linear equations, concept of a function, linear systems, algebra of polynomials, factoring of polynomials, algebra of rational expressions, literal equations, word problems involving linear, rational and quadratic models, integer and rational exponents, radical expressions, rational, radical and quadratic equations, complex numbers. 3 hours of mandatory class and lab meetings per week. Quantitative Literacy is a significant component of this course. MA 102 section QL is an on-line version of MA 102 and is intended primarily for students who have job conflicts or live a long distance from the campus. There are no campus based meetings with the on-line class. However, students in the on-line version of MA 102 are required to interact with peers and the instructor through an on-line format and should be able to work independently and be motivated self-starters who are confident in their ability to master mathematics. Prerequisites: MA 098 [Min Grade: C] or MPL 30 or EMA E

MA 105. Pre-Calculus Algebra. 3 Hours.
Functions from algebraic, geometric (graphical), and numerical points of view, including polynomial, rational, logarithmic, and exponential functions; inverse functions; systems of equations and inequalities; quadratic and rational inequalities; complex and real roots of polynomials; applications and modeling, both scientific and business. Supports development of quantitative literacy. Attendance at the first meeting is mandatory. May not be enrolled in Undergraduate Certificate. Lecture, online at least 80%. Quantitative Literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics. Prerequisites: MA 102 [Min Grade: C] or MPL 46 or EMA E

MA 106. Pre-Calculus Trigonometry. 3 Hours.
Trigonometric functions (circular functions) and their inverses, graphs, and properties; right triangle trigonometry and applications; analytical trigonometry, trigonometric identities and equations; polar coordinates; complex numbers; laws of sines and cosines; conic sections. Supports development of quantitative literacy. Attendance at the first meeting is mandatory. Quantitative Literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics. Prerequisites: MA 105 [Min Grade: C] or MPL 61 or EMA E

MA 107. Pre-Calculus Algebra and Trigonometry. 4 Hours.
Functions, their graphs and applications, including polynomial, rational, algebraic, exponential, logarithmic, and trigonometric functions. A fast-paced course designed as a review of the algebra and trigonometry needed in calculus. (MA107 is a combination of MA105 Pre-Calculus Algebra and MA106 Pre-Calculus Trigonometry taught in a single semester.) Satisfies core curriculum requirement in mathematics. Supports development of quantitative literacy. Attendance at the first meeting is mandatory. Quantitative literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics. Prerequisites: MA 102 [Min Grade: B] or MPL 68 or EMA E

MA 108. Introduction to Finite Mathematics. 3 Hours.
This course provides a hands on, individualized overview of finite mathematics and applications of mathematics for the liberal arts student. Topics include counting, permutations, combinations, basic probability, conditional probability, descriptive statistics, binomial and normal distributions, statistical inference, and additional selected topics. Students construct models of problem situations, translate verbal descriptions into mathematical form, interpret and create schematic representations of mathematical relationships, use quantitative evidence as a basis for reasoning, argument, and drawing conclusions, and communicate their results to an audience appropriately. This course is co-requisite with MA094L. May not be enrolled in Undergraduate Certificate. Quantitative Literacy is a significant component of this course.

MA 110. Finite Mathematics. 3 Hours.
An overview of topics of finite mathematics and applications of mathematics for the liberal arts student. Topics include counting, permutations, combinations, basic probability, conditional probability, descriptive statistics, binomial and normal distributions, statistical inference, and additional selected topics. Students construct models of problem situations, translate verbal descriptions into mathematical form, interpret and create schematic representations of mathematical relationships, use quantitative evidence as a basis for reasoning, argument, and drawing conclusions, and communicate their results to an audience appropriately. May not be enrolled in Undergraduate Certificate. Quantitative Literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics. Prerequisites: MA 094 [Min Grade: C] or MA 098 [Min Grade: C] or MA 102 [Min Grade: C] or MTH1 75 or MTH2 75 or MTH3 75 or MTH4 75 or MTH5 75 or MPL 30 or EMA E

MA 120. Introduction to Symbolic Logic. 3 Hours.
Modern theory of deductive inference. Emphasis on recognizing valid forms of reasoning. Truth-function theory and some concepts of one-variable quantification theory. May not be used to satisfy Core Curriculum requirement in mathematics.

MA 125. Calculus I. 4 Hours.
Limit of a function; continuity, derivatives of algebraic, trigonometric exponential, and logarithmic functions, application of derivative to extremal problems, optimization, and graphing; Newton method; the definite integral and its application to area problems; fundamental theorem of integral calculus, average value, and substitution rule. Quantitative literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics. Prerequisites: MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MTH4 75 or MTH5 75 or MPL 76 or EMA E or A02 29 or SAT2 680
MA 125L. Calculus I Lab. 0 Hours.
This course is a zero credit hours co-requisite lab designed to supplement the lectures. The emphasis will be on problem solving and examples of applications of the concepts discussed and presented during lectures. The laboratory will also use computer programs for problem-solving, visualization, plotting and simulation. The topics covered are: Limit of a function; continuity, derivatives of algebraic, trigonometric, exponential, and logarithmic functions, application of derivative to external problems, optimization, and graphing; Newton method; the definite integral and its application to area problems; fundamental theorem of integral calculus, average value, and substitution rule. Quantitative literacy is a significant component of this course.
Prerequisites: MA 106 (Min Grade: C) or MA 107 (Min Grade: C) or MPL 76 or EMA E

MA 126. Calculus II. 4 Hours.
Techniques of integration; applications in integration such as volume, arc length and work; infinite series, Taylor series; polar coordinates; parametric equations; plane and space vectors; lines and planes in space. Quantitative Literacy is a significant component of this course. This course meets the Core Curriculum requirements for Area III: Mathematics.
Prerequisites: MA 125 (Min Grade: C) or MA 225 (Min Grade: C) or MTHS 75

MA 160. Linear Algebra: Data and Models. 4 Hours.
The course teaches linear algebra mostly from a process point of view with multiple examples to engage conceptual understanding through noting commonalities of the basic structures of nite-dimensional Euclidean spaces. Beginning with two and three dimensional Euclidean spaces where algebraic and geometric viewpoints can be seen to correspond, we extend processing and understanding to higher dimensional spaces through software. The lab will run prepackaged computer programs for determining some basic structures from others. Throughout the course development, applications in areas such as analysis of data sets, biological models, genetics, imaging science, page ranking, optimization, financial models, cryptography, and more will be presented. No background in matrix operations or computer programming is required.
Prerequisites: MA 106 (Min Grade: C) or MPL 70

MA 168. Mathematics of Biological Systems I. 4 Hours.
The course teaches mathematical modeling as a tool for understanding the dynamics of biological systems. We will begin with the fundamental concepts of single-variable calculus, and then develop single- and multi-variable differential equation models of dynamical processes in ecology, physiology and other applications in which quantities change with time. The laboratory will run prepackaged computer programs for problem-solving, visualization, plotting and simulation. Basic programming concepts like program flow control and data structures will be introduced. No background in computer programming is required.
Prerequisites: MA 106 (Min Grade: C) or MA 107 (Min Grade: C) or MPL 70

MA 180. Introduction to Statistics. 3 Hours.
Descriptive and inferential statistics, probability distributions, estimation, hypothesis testing, One-way ANOVA, and linear regression. Quantitative Literacy is a significant component of this course.
Prerequisites: MA 102 (Min Grade: C) or MA 105 (Min Grade: C) or MA 106 (Min Grade: C) or MA 107 (Min Grade: C) or MA 110 (Min Grade: C) or MA 125 (Min Grade: C) or MA 225 (Min Grade: C) or MPL 46

MA 224. Intermediate Symbolic Logic. 3 Hours.
Full development of quantification theory, including identity and definite description, and soundness and completeness proofs. Skill in formal proof emphasized, as well as ability to express arguments from natural language in artificial language.
Prerequisites: MA 120 (Min Grade: C) or PHL 220 (Min Grade: C)

MA 225. Calculus I - Honors. 4 Hours.
Limit of a function; continuity, derivatives of algebraic, trigonometric, exponential, and logarithmic functions, application of derivative to extremal problems, optimization, and graphing; Newton method; the definite integral and its application to area problems; fundamental theorem of integral calculus, average value, and substitution rule. Students will be required to display an in-depth understanding of these topics through a complete justification of their work on tests and through participation in class projects. Quantitative literacy is a significant component of this course.
Prerequisites: MA 106 (Min Grade: C) or MA 107 (Min Grade: C) or MTHS 74 or MTHS 75 or MPL 76 or EMA E

MA 226. Calculus II - Honors. 4 Hours.
Techniques of integration; applications in integration such as volume, arc length and work; infinite series, Taylor series; polar coordinates; parametric equations; plane and space vectors; lines and planes in space. Quantitative Literacy is a significant component of this course.
Prerequisites: MA 225 (Min Grade: C) or MA 125 (Min Grade: C) or MTHS 75

MA 227. Calculus III. 4 Hours.
Vector functions, functions of two or more variables, partial derivatives, quadric surfaces, multiple integration and vector calculus, including Greens Theorem, curl and divergence, surface integrals, and Gauss’ and Stokes’ Theorem. This course meets the Core Curriculum requirements for Area III: Mathematics.
Prerequisites: MA 226 (Min Grade: C) or MA 226 (Min Grade: C)

MA 252. Introduction to Differential Equations. 3 Hours.
First order differential equations (separable, linear, exact, and additional non-linear examples using MAPLE), modeling with first order DE’s, examples of systems of first order DE’s, theory of higher order linear DE’s (homogeneous and non-homogeneous, superposition of solutions, linear independence and general solutions, initial and boundary value problems), solution of constant coefficient homogeneous linear equations, variation of parameters and Green’s functions with complicated cases done using MAPLE. Modeling projects in the course will emphasize the use of MAPLE to do the heavy lifting. Quantitative Literacy and Writing are significant components of this course. This course meets the Core Curriculum requirements for Area III: Mathematics.
Prerequisites: MA 126 (Min Grade: C) or MA 226 (Min Grade: C)

MA 260. Introduction to Linear Algebra. 3 Hours.
Linear equations and matrices; real vector spaces, basis, diagonalization, linear transformations; determinants, eigenvalues, and eigenvectors; inner product spaces, matrix diagonalization; applications and selected additional topics. This course meets the Core Curriculum requirements for Area III: Mathematics.
Prerequisites: MA 125 (Min Grade: C) or MA 225 (Min Grade: C)

MA 265. Math Tools for Engineering Problem Solving. 4 Hours.
An applied mathematics course designed to utilize the terminology and problem-solving approaches inherent to engineering, while completing the mathematical preparation of most engineering students. This course includes elements of MA 227 and MA 252.
Prerequisites: MA 126 (Min Grade: C) or MA 226 (Min Grade: C)
MA 268. Introduction to Mathematical Biology. 3 Hours.
This course, designed at the interface of several disciplines, targets undergraduate students in biology, mathematics, and engineering. We will review the biology of problems that arise in nature and medicine and study the mathematics that allows us to tackle these problems. This course serves as an introduction, by example, to multivariable calculus, discrete and continuous differential equations in one or more variables, vectors, matrices, linear and non-linear dynamical systems, and basic concepts of chaos. Biological topics may include single species and interacting population dynamics, modeling infectious and dynamic diseases, regulation of cell function, molecular interactions and receptor-ligand binding, biological oscillators, and an introduction to biological pattern formation. There will also be discussions of current topics of interest such as tumor growth and angiogenesis, HIV and AIDS, and control of the mitotic clock.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 298. Research in Mathematics. 1-12 Hour.
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics. Freshman or sophomore standing recommended.
Prerequisites: Permission of instructor.

MA 311. History of Mathematics I. 3,4 Hours.
Development of mathematical principles and ideas from an historical viewpoint, and their cultural, educational and social significance.
Prerequisites: MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

MA 312. History of Mathematics II. 3 Hours.
Development of mathematical principles and ideas from an historical viewpoint, and their cultural, educational and social significance.
Prerequisites: MA 311 [Min Grade: C]

MA 313. Patterns, Functions and Algebraic Reasoning. 3 Hours.
Problem solving experiences, inductive and deductive reasoning, patterns and functions, some concepts and applications of geometry for elementary and middle school teachers. Topics include linear and quadratic relations and functions and some cubic and exponential functions. Number sense with the rational number system including fractions, decimals, and percents will be developed in problem contexts. An emphasis will be on developing algebraic thinking and reasoning.
Prerequisites: MA 102 [Min Grade: C] or MA 105 [Min Grade: C] or MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 110 [Min Grade: C] or MA 125 [Min Grade: C] or MA 226 [Min Grade: C]

MA 314. Geometric and Proportional Reasoning. 3 Hours.
Problem solving experiences, inductive and deductive reasoning, concepts and applications of geometry and proportional reasoning. Topics include analysis of one-, two- and three-dimensional features of real objects, ratio and proportionally, similarity, and congruence, linear, area, and volume measurement, and the development of mathematically convincing arguments. An emphasis will be on developing geometric and proportional thinking and reasoning.
Prerequisites: MA 313 [Min Grade: C]

MA 315. Probabilistic and Statistical Reasoning. 3 Hours.
Descriptive and inferential statistics, probability, estimation, hypothesis testing. Reasoning with probability and statistics is emphasized.
Prerequisites: MA 313 [Min Grade: C]

MA 316. Numerical Reasoning. 3 Hours.
Develop an understanding of number and improve numerical reasoning skills specifically with regard to place value, number relationship that build fluency with basis facts, and computational proficiency; developing a deep understanding of numerous diverse computational algorithms; mathematical models to represent fractions, decimals and percents, equivalencies and operations with fractions, decimals and percents; number theory including order of operations, counting as a big idea, properties of number, primes and composites, perfect, abundant and significant numbers, and figurate numbers; inductive and deductive reasoning with number.
Prerequisites: MA 313 [Min Grade: C]

MA 317. Extending Algebraic Reasoning. 3 Hours.
Extension of algebraic and functional reasoning to polynomials, rational, exponential, and logarithmic functions; problem-solving involving transfer among representations (equation, graph, table); proof via symbolic reasoning, contradiction, and algorithm; interpretation of key points on graphs (intercepts, slope, extrema); development of facility and efficiency in manipulating symbolic representations with understanding; appropriate use of technology and approximate versus exact solutions; functions as models.
Prerequisites: MA 313 [Min Grade: C]

MA 360. Scientific Programming. 3 Hours.
Programming and mathematical problem solving using Matlab, Python, FORTRAN or C++. Emphasizes the systematic development of algorithms and numerical methods. Topics include computers, floating point arithmetic, iteration, GNU/Linux operating system, functions, arrays, Matlab graphics, image processing, robotics, solving linear systems and differential equation arising from practical situations, use of debuggers and other debugging techniques, and profiling; use of callable subroutine packages like LAPACK and differential equation routines; parallel programming. Assignments and projects are designed to give the students a computational sense through complexity, dimension, inexact arithmetic, randomness, simulation and the role of approximation.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 361. Mathematical Modeling. 3 Hours.
Mathematical modeling using computer software, including spreadsheets, systems dynamics software, and computer algebra systems; connections to calculus and functions are emphasized. Students make presentations to the class; justification of mathematical claims and quality of student presentations are assessed. Quantitative Literacy is a significant component of this course.
Prerequisites: MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

MA 398. Research in Mathematics. 1-12 Hour.
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Junior standing recommended. Permission of instructor required.

MA 411. Integrating Mathematical Ideas. 3 Hours.
This course will integrate ideas from algebra, geometry, probability, and statistics. Emphasis will be on using functions as mathematical models, becoming fluent with multiple representations of functions, and choosing the most appropriate representations for solving a specific problem. Students will be expected to communicate mathematics verbally and in writing through small group, whole group, and individual interactions.
Prerequisites: (MA 125 [Min Grade: C] or MA 225 [Min Grade: C]) and MA 314 [Min Grade: C](Can be taken Concurrently) or MA 316 [Min Grade: C]
MA 418. Statistics for Teachers. 3 Hours.
Descriptive and inferential statistics, probability distributions, estimation, hypotheses testing, regression. Writing assignment on a project drawing from the above topics. Quantitative Literacy is a significant component of this course.
Prerequisites: MA 102 [Min Grade: C] or MA 105 [Min Grade: C] or MA 106 [Min Grade: C] or MA 107 [Min Grade: C] or MA 110 [Min Grade: C] or MA 125 [Min Grade: C] or MA 225 [Min Grade: C] or MPL 46

MA 419. Special Topics. 1-4 Hour.
Topics vary; may be repeated for credit.
Prerequisites: MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

MA 434. Algebra I: Linear. 3 Hours.
Abstract vector spaces. Linear transformations: ranges and null spaces; matrix representation; invertibility and isomorphism; the change of coordinate matrix; transformation of a matrix of a linear map under a change of basis. Elementary matrix operations and elementary matrices; column and row spaces of a matrix; rank. Theory of systems of linear equations. Inner product spaces: inner products and norms; orthogonal bases; Gram-Schmidt orthogonalization process and orthogonal complements; self-adjoint operators; spectral theorem. Generalized eigenvectors; Jordan form. Applications.
Prerequisites: MA 260 [Min Grade: C]

MA 435. Algebra II: Modern. 3 Hours.
Rings, including the rings of integers and of polynomials, integral domains, fields and groups. Homomorphism, isomorphism. As time permits, Galois theory, semi-groups, quotient groups, models, or other areas of algebra may be included. Students present proofs from a list of pre-assigned theorems to the class. Logical correctness and proper mathematical proof-writing style are assessed.
Prerequisites: MA 434 [Min Grade: C] or MA 260 [Min Grade: C]

MA 440. Advanced Calculus I. 3 Hours.
Real numbers, sequences and series, continuity, differential and integral calculus, exponential and logarithm functions, sine and cosine functions. Students present proofs from a list of pre-assigned theorems to the class. Written versions of the proofs are posted for easy access in subsequent proofs. Logical correctness and proper mathematical proof-writing style are assessed. Writing and Quantitative Literacy are significant components of the course.
Prerequisites: MA 227 [Min Grade: C]

MA 441. Advanced Calculus II. 3 Hours.
Real numbers, sequences and series, continuity, differential and integral calculus, exponential and logarithm functions, sine and cosine functions. Students present proofs from a list of pre-assigned theorems to the class. Written versions of the proofs are posted for easy access in subsequent proofs. Logical correctness and proper mathematical proof-writing style are assessed. Writing and Quantitative Literacy are significant components of the course.
Prerequisites: MA 440 [Min Grade: C]

MA 444. Vector Analysis. 3 Hours.
Review and application of multiple integrals; Jacobians and change of variables in multiple integrals; line and surface integrals; Green, Gauss, and Stokes theorems, with applications to physical sciences and computation in spherical and cylindrical coordinates.
Prerequisites: MA 227 [Min Grade: C]

MA 445. Complex Analysis. 3 Hours.
Analytic functions, complex integration and Cauchys theorem, Taylor and Laurent series, calculus of residues and applications, conformal mappings.
Prerequisites: MA 227 [Min Grade: C]

MA 453. Fourier Analysis. 3 Hours.
Fourier series, including odd/even functions expansions, complex power series, generalized Fourier series. Convergence, applications to partial differential equations. Fourier transform; basic properties, inversion of the FT, windowing, relation to the Laplace transform. Applications to partial differential equations. Wavelets and signal processing basic functions, transforming wavelets, short time Fourier transform.
Prerequisites: MA 252 [Min Grade: C]

MA 454. Intermediate Differential Equations. 3 Hours.
Topics from among Frobenius series solutions, Sturm-Liouville systems, nonlinear equations, and stability theory.
Prerequisites: MA 252 [Min Grade: C]

MA 455. Partial Differential Equations I. 3 Hours.
Classification of second order partial differential equations; background on eigenfunction expansions and Fourier series; integrals and transforms; solutions of the wave equations, reflection of waves; solution of the heat equations in bounded and unbounded media; Laplace's equation, Dirichlet and Neumann problems. Written project reports required. Quantitative Literacy and Writing are significant components of this course.
Prerequisites: MA 252 [Min Grade: C]

MA 456. Partial Differential Equations II. 3 Hours.
Classification of second order partial differential equations; background on eigenfunction expansions and Fourier series; integrals and transforms; solution of the wave equations, reflection of waves; solution of the heat equation in bounded and unbounded media; Laplace's equation, Dirichlet and Neumann problems.
Prerequisites: MA 455 [Min Grade: C]

MA 460. Mathematical Game Theory. 3 Hours.
This course is an introduction to mathematical game theory for those that have good understanding of calculus. Unlike calculus and optimization, where one learns how to maximize functions when the payoff depends only on your own choices, game theory deals with situations in which payoff depends not only on your own choices but also on the choices of others. Like optimization, game theory is defined by the problems it deals with, not by the mathematical techniques that are used to solve them. These problems come from diverse fields ranging from evolutionary biology and animal behavior to political science and economics. Examples are drawn from scenarios such as traffic accidents, crime-control strategies, climate change negotiations etc. The course provides substantial treatment of evolutionary game theory, where strategies are not chosen through rational analysis, but emerge by virtue of being successful. This part of game theory requires understanding of calculus and some differential equations and is the most relevant to biology. It also explains how human societies evolve. Problem sets to help develop the ability necessary to master game theory tools will be discussed and assigned at the end of each chapter. Quantitative literacy is a significant component of this course.
Prerequisites: MA 125 [Min Grade: C] or MA 225 [Min Grade: C]
MA 461. Modeling with Partial Differential Equations. 3 Hours.
Practical examples of partial differential equations; derivation of partial differential equations from physical laws; introduction to MATLAB and its PDE Tool-box, and COMSOL using practical examples; an overview of finite difference and finite element solution methods; specialized modeling projects in topics such as groundwater modeling, scattering of waves, medical and industrial imaging, continuum mechanics and deformation of solids, fluid mechanics including the class boat race, financial derivative modeling, and acoustic and electromagnetic wave applications. Written project reports required for all homework assignments. Quantitative Literacy and Writing are significant components of this course.
Prerequisites: MA 252 [Min Grade: C]

MA 462. Intro to Stochastic Differential Equations. 3 Hours.
Stochastic differential equations arise when random effects are introduced into the modeling of physical systems. Topics include Brownian motion and Wiener processes, stochastic integrals and the Itô calculus, stochastic differential equations, and applications to financial modeling, including option pricing.
Prerequisites: MA 485 [Min Grade: C]

MA 466. Introduction to Optimization. 3 Hours.
Optimization is important in many decision making problems in various areas like engineering, economics and machine learning. Optimization theory deals with finding the best solution(s) or variables of a given objective function. Recently, the area of optimization has received much attention due to the development of highly efficient computational methods for data analysis. The scope of this course covers linear algebra, unconstrained optimization, linear programming, and nonlinear constrained optimization. The topics include linear algebra, linear program, duality, network flows, simplex method, non-simplex method, gradient and conjugate methods, neural network, genetic algorithm and convex optimization. The course will also introduce optimization algorithms and codes via python and matlab.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 467. Gas Dynamics. 3 Hours.
Euler's equations for inviscid flows, rotation and vorticity, Navier-Stokes equations for viscous flows, hyperbolic equations and characteristics, rarefaction waves, shock waves and entropy conditions, the Riemann problem for one-dimensional gas flows, numerical schemes.
Prerequisites: MA 252 [Min Grade: C] and MA 360 [Min Grade: C]

MA 468. Numerical Analysis I. 3 Hours.
Programming for numerical calculations, round-off error, approximation and interpolation, numerical quadrature, and solution of ordinary differential equations. Practice on the computer.
Prerequisites: MA 227 [Min Grade: C] or MA 252 [Min Grade: C]

MA 469. Numerical Analysis II. 3 Hours.
Iterative solution of systems of nonlinear equations, evaluation of eigenvalues and eigenvectors of matrices, applications to simple partial differential equations, special topics in numerical linear algebra. Practice on the computer.
Prerequisites: MA 468 [Min Grade: C]

MA 470. Differential Geometry. 3 Hours.
Theory of curves and surfaces: Frenet formulas for curve, first and second fundamental forms of surface; global theory; abstract surfaces, manifolds, Riemannian geometry.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 472. Geometry I. 3 Hours.
The axiomatic method; Euclidean geometry including Euclidean constructions, basic analytic geometry, transformational geometry, and Klein's Erlangen Program. Students present proofs from a list of pre-assigned theorems to the class. Logical correctness and proper mathematical proof-writing style are assessed.
Prerequisites: MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

MA 473. Geometry II. 3 Hours.
Analytical geometry, Birkhoff's axioms, and the complex plane; structure and representation of Euclidean isometries; plane symmetries; non-Euclidean(hyperbolic) geometry and non-Euclidean transformations; fractal geometry; algorithmic geometry. Course integrates intuition/exploration and proof/explanation.
Prerequisites: MA 472 [Min Grade: C] and MA 260 [Min Grade: C] or MA 434 [Min Grade: C]

MA 474. Introduction to Topology I. 3 Hours.
Essence and consequences of notion of continuous function developed. Topics include metric spaces, topological spaces, compactness, connected-ness, and separation.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 475. Introduction to Topology II. 3 Hours.
Essence and consequences of notion of continuous function developed. Topics include metric spaces, topological spaces, compactness, connectedness, and separation.
Prerequisites: MA 474 [Min Grade: C]

MA 480. Introduction to Statistics. 3 Hours.
Descriptive and inferential statistics, probability distributions, estimation, hypothesis testing. Recommended that two years of high school algebra or MA 102 has been completed before taking course. MA 480 does not count toward any math major or minor.

MA 481. Mathematical Finance. 3 Hours.
Prerequisites: MA 125 [Min Grade: C] and MA 485 [Min Grade: C]

MA 485. Probability. 3 Hours.
Probability spaces, combinatorics, conditional probabilities and independence, Bayes rule, discrete and continuous distributions, mean value and variance, moment generation function, joint distributions, correlation, Central Limit Theorem, Law of Large Numbers, random walks, Poisson process.
Prerequisites: MA 126 [Min Grade: C] or MA 226 [Min Grade: C]

MA 486. Mathematical Statistics. 3 Hours.
Sampling techniques and data analysis, Simulation, Point estimation, Confidence intervals, Sufficient statistics, Rao-Cramer lower bound, Tests for binomials, Tests for normals, Goodness-of-f test, Contingency tables, Two factor analysis, Regression, Order statistics, Nonparametric methods: Wilcoxon test, Run test, and Kolmogorov-Smirnov test. A computer project that involves a written report. Quantitative Literacy and Writing are significant components of this course.
Prerequisites: MA 485 [Min Grade: C]
**MA 490. Mathematics Seminar. 1-3 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites Permission of instructor.

**MA 491. Special Topics in Mathematics. 1-3 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 492. Special Topics in Mathematics. 1-3 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 493. Special Topics in Mathematics. 1-3 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 494. Special Topics in Mathematics. 1-6 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 495. Special Topics in Mathematics. 1-6 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 496. Special Topics in Mathematics. 1-12 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics.

**MA 497. Research Methods in Mathematics. 1-3 Hour.**
Through experience in designing and carrying out investigations, learn how scientists and mathematicians gain knowledge, evaluate scientific and mathematical claims when they conduct, and design and carry out investigations to answer new questions. Work is closely coordinated with the work of students from other content disciplines so that students see the similarity and differences of research methods in their own field as compared with those of science and mathematics inquiry as a whole. Enrollment in UABTeach is required.

**Prerequisites:** MA 125 [Min Grade: C] or MA 225 [Min Grade: C]

**MA 498. Research in Mathematics. 1-12 Hour.**
This course covers special topics in mathematics and the applications of mathematics. May be repeated for credit when topics vary. Prerequisites vary with topics. Senior standing recommended.

**MA 499. Honors Research in Mathematics. 1-12 Hour.**
Mentored research in mathematics leading to a written research report and a public presentation in the form of a talk or poster. Admission restricted to students admitted to Honors in Mathematics. Permission of instructor required.