APPLIED MATHEMATICS - PROFESSIONAL MASTER OF SCIENCE (MSAM)

CU Boulder’s professional master’s degree in applied mathematics is designed to give students the technical knowledge and professional skills to be highly successful in careers related to data science, statistics, applied mathematics and engineering.

Coursework culminating in a comprehensive final project offers students strong preparation in mathematics, statistics and computing at the heart of the big data revolution. In addition, students will have access to workshops and courses that help develop valuable professional skills, including communication, collaboration, presentation, organizational and networking skills. As a part of our program, students engage in a hands-on, experiential education, with opportunities for networking with campus faculty and off-campus professionals.

Our internationally recognized faculty have both academic and industrial experience. Many are fellows of professional societies, including the Society for Industrial and Applied Mathematics, the American Mathematical Society, the American Statistical Association and the American Physical Society.

Specializations

Statistics and Data Science Specialization

Students in the program will have the option to specialize in Statistics and Data Science or customize their own educational plan. The Statistics and Data Science specialization enables students to develop the foundational tools needed to analyze and interpret data, including complex and high dimensional datasets. In addition, students will have the opportunity to participate in the department's Laboratory for Interdisciplinary Statistical Analysis (LISA) (https://www.colorado.edu/lab/lisa). Here, students will gain valuable collaboration skills and foster relationships with faculty and industry professionals.

Customized Specialization

Students not wishing to specialize in statistics and data science can forge their own path with a customized educational track that capitalizes on the Applied Mathematics Department's numerous strengths, including computational mathematics, dynamical systems, nonlinear sciences, physical applied mathematics, statistics and applied probability.

For more information, see the department’s Professional MS in Applied Mathematics (https://www.colorado.edu/graduateschool/professional-masters-programs/professional-ms-applied-mathematics) webpage.

Requirements

Prerequisites

Prerequisites for graduate study in applied mathematics include three semesters of calculus and a course in differential equations and linear algebra. The overall grade point average for mathematics and applied mathematics must be B or better.

Other strongly recommended courses are:

Strongly Recommended Prerequisites

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPM 3310</td>
<td>Matrix Methods and Applications</td>
<td>3</td>
</tr>
<tr>
<td>One of the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>APPM 3570</td>
<td>Applied Probability</td>
<td>3</td>
</tr>
<tr>
<td>MATH 4510</td>
<td>Introduction to Probability Theory</td>
<td>3</td>
</tr>
</tbody>
</table>

Course Requirements

The department requires a master’s degree candidate to complete an approved program of study consisting of at least 30 credit hours, at least 18 of which must be applied mathematics or statistics courses at the 5000 level or above. A grade of C (2.0) or higher must be attained in each course.

Generally, the following courses do not count toward the 30-credit-hour requirement: APPM 5350, APPM 5360 and APPM 5720.

Course Requirements

Note: The APPM 5720 course number is used for a variety of courses that are either run for the first time or on an ad hoc basis. When appropriate, the Graduate Committee may decide that a particular version of this course should count towards graduate credits. If a student would like to count credits from APPM 5720 toward an APPM graduate degree, advice should be sought from the Director of the PMD program on whether this would be permissible.

All master's degree students must complete one yearlong 5000-level course sequence in APPM or STAT.

MS candidates must take a yearlong 5000-level graduate sequence outside of applied mathematics in an area where mathematics or statistics has significant application. This sequence must be approved by the PMD Director.

Upon approval by petition to the PMD Director, up to 6 credit hours may be taken in 4000-level courses in other departments, provided members of the graduate faculty teach those courses.

Culminating Experience (CE)

There are two options for completing a CE. Each option has a written and presentation component. Students in the program will propose and discuss a CE option with the PMD Director before approval is granted.

Option I: Project

A CE project is intended to have goals that are different from a traditional master's thesis. In particular, students working on a project are expected to fulfill any of the following three goals: (1) master an important set of mathematical or statistical methods used in industry; (2) gain experience working with a large, high dimensional, or "messy" dataset; or (3) gain exposure to some tools (e.g., SQL and database management) that aren't typically taught in the program but that are useful for future employment.

- Students interested in statistics and data science are encouraged to complete their CE project with LISA. The most natural way to do this would be to produce a written report and presentation of a collaborative project from STAT 5680 Statistical Collaboration or STAT 5690 Advanced Statistical Collaboration.
- Students pursuing areas other than statistics and data science would propose a project to a potential advisor. If interested, the student and advisor would come to an agreement on the work required to meet
goals (1)–(3) above. Such projects do not need to meet the criteria of a formal master’s thesis.

Option II: Internship or Fellowship
Students who secure an internship or fellowship related to applied mathematics, statistics, or data science while in the program can use their work as part of their CE. Students choosing this CE option should work closely with their PMD advisor to decide what components will be necessary for successful completion of the CE (e.g., a presentation or written report of the details of the internship/fellowship).

Plan(s) of Study
Specialization in Statistics and Data Science
Students will have the option to specialize in statistics and data science. This specialization is meant to give students the foundational tools for analyzing data, including complex and high dimensional datasets. There are four required courses and many electives coming from two categories:

- Probability and Statistics Theory: Courses in this category introduce the theory of probability and stochastic processes, and the foundations of statistical inference. (Courses: STAT 5520 Introduction to Mathematical Statistics or STAT 5530 Mathematical Statistics (one is required); STAT 5100 Markov Processes, Queues, and Monte Carlo Simulations; STAT 5540 Introduction to Time Series.)

- Statistical Modeling and Data Science: Courses in this category provide students with the tools to model and analyze data, perform predictive analyses, and apply theory to solve important scientific problems. (Courses: STAT 5000 Statistical Methods and Application I (required); STAT 5010 Statistical Methods and Applications II (required); STAT 5400 ; STAT 5610 Statistical Learning (required); STAT 5430 Spatial Statistics; STAT 5630 Computational Bayesian Statistics)

Students interested in statistics and data science are encouraged to complete their CE project through the department’s Laboratory for Interdisciplinary Statistical Analysis (https://www.colorado.edu/lab/lisa) (LISA). The most natural way to do this would be to produce a written report and presentation of a collaborative project from STAT 5680 Statistical Collaboration or STAT 5690 Advanced Statistical Collaboration. Students who do not take both STAT 5680 and STAT 5690 will have a deficit of 3 credit hours; such deficits can be filled in by elective coursework as determined with the faculty advisor to reach the 30 credit hours required for the degree. This option will not require a final examination with committee.

The table below gives a sample program representing one possible scenario for successfully completing the degree with a statistics and data science specialty. Other scenarios are possible.

Customized Specialization
Students are able to build a customized specialization based on their own interests. Such specializations should be designed with the professional MS director within the first year of the program. The plan listed below gives one possibility.

### Course Title Credit Hours

<table>
<thead>
<tr>
<th>Year One</th>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 5000</td>
<td>Statistical Methods and Application I</td>
<td>3</td>
</tr>
<tr>
<td>STAT 5520</td>
<td>Introduction to Mathematical Statistics</td>
<td>3</td>
</tr>
<tr>
<td>APPM/STAT Elective</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>STAT 5010</td>
<td>Statistical Methods and Applications II</td>
<td>3</td>
</tr>
<tr>
<td>Part 1 Out of Department Sequence</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Part 2 Out of Department Sequence</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

| Total Credit Hours | 15 |

### Year Two

<table>
<thead>
<tr>
<th>Title</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>STAT 5400</td>
<td>3</td>
</tr>
<tr>
<td>STAT 5610</td>
<td>Statistical Learning</td>
</tr>
<tr>
<td>Part 2 Out of Department Sequence</td>
<td>3</td>
</tr>
<tr>
<td>STAT 5630</td>
<td>Computational Bayesian Statistics</td>
</tr>
<tr>
<td>STAT 5680</td>
<td>Statistical Collaboration</td>
</tr>
</tbody>
</table>

### Culminating Experience

| Credit Hours | 15 |

### Educational Goals

#### Content Knowledge

- Provide students with foundational knowledge in areas of applied mathematics, statistics or data analysis beyond the standard undergraduate curriculum.

- Statistics and Data Science Specialization: Provide students with foundational knowledge in (1) probability and statistical theory and (2) statistical modeling and data science.

- Provide students with the skills to write efficient, reproducible code in at least one programming language (e.g., R, Matlab, Python).

- Provide students with the skills to interpret code and output from at least one programming language.

#### Professional Skills

- Provide students with a set of industry-sought professional skills, including data analysis, communication, collaboration, presentation, organizational, and networking skills.

- Teach students to utilize their foundational knowledge in applied mathematics, statistics, or data analysis, and their professional skills, to solve real-world science, engineering, social science, or data analysis problems.

- Make available a number of opportunities for students to gain hands-on, real-world experience. Such opportunities include internships, fellowships, and professional collaborations through LISA.