

# 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, mathematical biology, mathematical geosciences, applied nonlinear PDEs and dynamics, and stochastic processes and applications.

For more information, see the department's Professional MS in Applied Mathematics (<https://www.colorado.edu/amath/academics/professional-masters-degree/>) webpage.

## Bachelor's–Accelerated Master's Degree Program

Students may earn this degree as part of the Bachelor's–Accelerated Master's (BAM) degree program, which allows currently enrolled CU Boulder undergraduate students the opportunity to earn a bachelor's and master's degree in a shorter period of time.

For more information, see the Accelerated Master's tab for the associated bachelor's degree(s): Statistics and Data Science - Bachelor of Arts (BA)

(<https://catalog.colorado.edu/undergraduate/colleges-schools/arts-sciences/programs-study/applied-mathematics/statistics-data-science-bachelor-arts-ba/#acceleratedmasterstext>)

## Requirements

### Prerequisites

The MS in applied mathematics is designed to further the strong math and computer science skills that candidates already demonstrate. Our program works well for those already working and practicing mathematics who wish to extend their knowledge and skill.

Equivalent recommended courses are:

Code	Title	Credit Hours
<b>Equivalent Prerequisites</b>		
APPM 3310	Matrix Methods and Applications	3
One of the following:		
APPM 3570	Applied Probability	3
MATH 4510	Introduction to Probability Theory	3

### 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. Maintain a GPA of 3.0 or better and earn at least a C grade in each course.

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

*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, they should speak with their advisor.

MS candidates must take two 5000-level graduate courses (6 credits) outside of applied mathematics in an area where mathematics or statistics has significant application. This sequence must be approved by the student's advisor.

Upon approval by petition to the professional MS 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)

Our unique program allows students to complete a Culminating Experience project (CE) instead of a master's thesis. This flexible, student-driven, industry-oriented project allows graduates to obtain deep knowledge and skills working with data that address scientific research issues. The CE project not only develops applicable skills for our master's degree students, but it is also highly regarded by companies, researchers and universities that employ our graduates.

There are two options for completing a CE. Each option must have a written and presentation component. See here ([https://www.colorado.edu/amath/sites/default/files/attached-files/ce\\_deliverables.pdf](https://www.colorado.edu/amath/sites/default/files/attached-files/ce_deliverables.pdf)) for information on the required written and presentation deliverables. Students in the program will propose and

discuss a CE option with their advisor before approval is granted. CE projects do not require a final examination with a committee.

### 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 their advisor and if applicable a potential co-advisor in that area of study. If interested, the student and co-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 advisor to determine successful completion of the CE. With approval from their advisor, students who choose this option can enroll in our CE independent study course APPM 6930 to receive credit for the internship or fellowship.

## Specializations

### Specialization in Statistics and Data Science

Students have the option to specialize in statistics and data science. This specialization gives students the foundational tools for analyzing data, including complex and high dimensional datasets. There are four required courses and many electives coming from the following categories:

- **Probability and statistics theory:** Courses in this category introduce the theory of probability and stochastic processes, and the foundations of statistical inference.
- **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.
- **Professional development and collaboration skills:** Courses in this category train students to become effective interdisciplinary collaborators. Skills taught in these courses include communicating statistics to non-statisticians, reproducible workflows and ethical decision-making.

For a list of courses that fall within these categories, visit the department website (<https://www.colorado.edu/amath/ms-applied-mathematics/degree-specializations/>).

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 approved by your advisor to reach the 30 credit hours required for the degree.

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.

Course	Title	Credit Hours
<b>Year One</b>		
STAT 5000	Statistical Methods and Application I (encouraged but optional based on background; an approved elective can be taken as an alternative)	3
STAT 5520 or STAT 5530	Introduction to Mathematical Statistics or Mathematical Statistics	3
APPM/STAT Elective		3
STAT 5010 or STAT 5310	Statistical Methods and Applications II or	3
Part 1 Out of Department Sequence		3
<b>Credit Hours</b>		<b>15</b>
<b>Year Two</b>		
STAT 5400	Advanced Statistical Modeling	3
STAT 5610	Statistical Learning	3
Part 2 Out of Department Sequence		3
STAT 5630	Computational Bayesian Statistics	3
STAT 5680	Statistical Collaboration	3
Culminating Experience		
<b>Credit Hours</b>		<b>15</b>
<b>Total Credit Hours</b>		<b>30</b>

### Customized Specialization

Students can forge their own path with a customized educational track based on their own interests. Many students choose to capitalize on the department's numerous strengths, including computational mathematics, statistics and data science, physical applied mathematics, mathematical biological and social sciences, and mathematical geosciences. Please see our Specialization Page (<https://www.colorado.edu/amath/ms-applied-mathematics/degree-specializations/>) for an example customized specialization.

Such specializations should be designed with the MS director within the first year of the program.

## 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, (2) statistical modeling and data science and (3) professional development and collaboration skills.
  - Customized specialization: Provide students with foundational knowledge in one of the Department of Applied Mathematics'

core research areas: computational mathematics, mathematical biology, mathematical geosciences, applied nonlinear PDEs and dynamics, or stochastic processes and applications.

- Provide students with the skills to write efficient, reproducible code in at least one programming language (e.g., R and 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 the Laboratory for Interdisciplinary Statistical Analysis (<https://www.colorado.edu/lab/lisa/>) (LISA).