APPLIED MATHEMATICS - DOCTOR OF PHILOSOPHY (PHD)

With internationally recognized faculty and a strong commitment to its graduate program, the Department of Applied Mathematics at CU Boulder strives to provide graduate students a high-quality education and training in applied mathematics while preparing them for careers in industry, laboratories and the academic professions.

The department fosters extensive interaction between students and faculty to provide a tailored educational experience in applied mathematics. Currently, the department has both faculty (https://www.colorado.edu/amath/directory/) and affiliated faculty (https://www.colorado.edu/amath/academics/graduate-students/affiliated-faculty/) from other academic departments and colleges. A PhD student can be advised by core faculty or co-advised by an affiliate involved in applied mathematics which creates a definitively unique learning experience in many areas of physical, biological, computational or engineering sciences. With the breadth of such a diverse faculty, a student can explore their academic and research interests through the investigation of numerous ongoing faculty projects.

Many of our PhD students have had the opportunity to conduct their research at world-class institutes located right here in Boulder such as the National Center for Atmospheric Research, National Institute of Standards and Technology, and the National Oceanic and Atmospheric Administration. Our students have the opportunity to not only work directly with organizations here in Boulder but also the National Renewable Energy Lab and the Laboratory for Atmospheric and Space Physics, along with many other national research laboratories.

The Department of Applied Mathematics offers coursework and research leading to the PhD degree in applied mathematics. The aim of the department is to train graduate students to perform independent research on the methods and applications of applied mathematics. Research areas represented in the department include:

- Computational mathematics
- Mathematical biology
- Mathematical geosciences
- Applied nonlinear PDEs and dynamics
- Statistics and data science
- Stochastic processes and applications

For more information on the department and degree requirements, download the supplement to the catalog (http://www.colorado.edu/amath/prospective-students/graduate/supplement-course-catalog-degree-requirements/) or visit the Applied Mathematics (http://www.colorado.edu/amath/) website.

PhD with Certificate in Interdisciplinary Quantitative Biology

Applied mathematicians interested in collaborations with bioscientists will need a breadth of knowledge in quantitative bioscience to be successful. The interdisciplinary quantitative biology (IQ biology) graduate certificate (https://catalog.colorado.edu/graduate/colleges-schools/interdisciplinary-programs/interdisciplinary-quantitative-biology-graduate-certificate/) program emphasizes training at the intersection of biochemistry, biology, computer science, engineering, applied mathematics and physics. The PhD in applied mathematics with a certificate in IQ biology will strengthen this training with additional foundations in numerical and mathematical analysis, probability and statistics, mathematical biology and network analysis.

Candidates interested in this program should apply directly to IQ biology and select applied mathematics as one of their graduate programs of interest. In addition to satisfying the requirements for the PhD in applied mathematics, students in this program must take 12 credit hours in three IQ biology core courses (Quantitative Biology Foundations, Statistics and Computations for Genomes and Meta-Genomes and Forces in Biology), which can serve as the out-of-department sequence for the PhD, as well as three 10-week rotations in labs associated with the IQ biology program.

For more information, visit the BioFrontiers Institute's IQ Biology PhD Program (http://iqbiology.colorado.edu/) website.

Requirements

Required Courses and Credits

A minimum of 60 credits is required for the degree, including 30 credits in courses numbered 5000 or above (APPM 5350, APPM 5360, STAT 5000 and APPM 5720 generally do not count toward this requirement) and 30 credits of applied math dissertation credit.

A grade of B- or higher must be attained in each course. PhD students must maintain a grade point average of 3.0 or better each semester.

Code	Title	Credit Hours
Required Core Sequences and Seminars		**15**
APPM 5440 & APPM 5450	Applied Analysis 1 and Applied Analysis 2	
APPM 5600 & APPM 5610	Numerical Analysis 1 and Numerical Analysis 2	
APPM 7400	Topics in Applied Mathematics (PhD students will take a 1-credit seminar three times, in the following topics: Teaching Excellence, Intro to Research, Graduate Research)	
Third Required Sequence (Student's Choice)		**6**
Choose between PDEs and Statistics Sequences. Some options are listed below.		
APPM 5470 & APPM 5430	Methods of Applied Mathematics: Partial Differential and Integral Equations and Methods in Applied Mathematics: Applications of Complex Variables	
or APPM 5460	Methods in Applied Mathematics: Dynamical Systems and Differential Equations	
or APPM 5480	Methods of Applied Mathematics: Approximation Methods	
STAT 5530 & STAT 5540	Mathematical Statistics and Introduction to Time Series	
or STAT 5100	Markov Processes, Queues, and Monte Carlo Simulations	
or STAT 5400	Advanced Statistical Modeling	

Elective(s): any 3-credit APPM class OR any three 1-credit seminars below		3
APPM 8000	Colloquium in Applied Mathematics	
APPM 8100	Seminar in Dynamical Systems	
APPM 8300	Nonlinear Waves Seminar	
APPM 8400	Mathematical Biology Seminar	
APPM 8500	Statistics, Optimization and Machine Learning Seminar	
APPM 8600	Seminar in Computational Mathematics	
Out-of-department Sequence		**6**
Choose two courses in an area where your research and mathematics have significant application. Approval of the sequence from the graduate committee chair is required.		
Dissertation		**30**
APPM 8990	Doctoral Dissertation	
Total Credit Hours		**60**

Exams

Preliminary Exams

- Doctoral students must take and pass two preliminary exams by August at the end of their first year. Exams are graded pass/fail.
- In January, first-year PhD students can choose to take either Partial Differential Equations or Statistics.
- In May, first-year PhD students can choose to take either Applied Analysis or Numerical Analysis.
- Makeup exams are offered in August. Students may only make up exams in areas they have taken before.
- Students may not take any exam more than twice.

Comprehensive Exams

The purpose of the comprehensive exam is to ensure that the student has a sufficient grasp of the fundamentals of the chosen thesis area to begin research, the ability to exchange ideas and information with the members of the examining board (thesis committee) and a broad base of knowledge in applied mathematics.

Before the comprehensive exam, the PhD student must submit a 5–10 page thesis proposal, complete with motivation for the topic and references to key papers, to each member of the thesis committee. This proposal should be written in consultation with the chair of the thesis committee.

The exam will consist of a presentation by the student on his/her research proposal for a maximum of one hour in length, followed by a questioning period of up to one additional hour. The presentation portion is open to all faculty and students in the program.

Students will need to be registered in classes for the semester they are going to complete their examination for it to count toward that semester. This includes the summer semester.

- Select committee (see rules on Exam Report) and schedule comprehensive date and location. Then inform Graduate Coordinator (amgradco@colorado.edu).
- Complete Doctoral Comprehensive Exam form (https://www.colorado.edu/graduateschool/content/doctoral-comprehensive-exam/) for committee approval (select comprehensive; at least 3 weeks prior to Comp Date).
- Submit title and abstract to amassist@colorado.edu to post in department (at least 2 weeks prior to comp date) See example

(https://www.colorado.edu/amath/sites/default/files/attached-files/comps_or_thesis_announcement_example.pdf) or .tex file. (https://www.colorado.edu/amath/sites/default/files/attached-files/comps_or_thesis_announcement_template.tex)

- Complete Candidacy application (https://www.colorado.edu/graduateschool/academics/forms-current-students/) to PhD.

Dissertation Defense

The exam will consist of a presentation by the student on his/her research proposal, followed by a questioning period of up to one additional hour. The presentation portion is open to all faculty and students in the program.

Students will need to be registered in classes for the semester they are going to complete their examination for it to count towards that semester. This includes the summer semester.

- Select committee members (see rules on Exam form) and inform the graduate coordinator.
- Complete Doctoral Exam f (http://www.colorado.edu/GraduateSchool/academics/_docs/docexam-fillable.pdf)orm (https://www.colorado.edu/graduateschool/content/doctoral-final-examination-form/) for committee approval (at *least* 2 weeks prior to Defense Date).
- Submit thesis to Graduate School electronically (https://www.colorado.edu/graduateschool/academics/thesis-dissertation-submission/) (contact graduate coordinator for details).
  - Submit a Thesis Approval Form (https://www.colorado.edu/graduateschool/content/thesis-approval-form/) (TAF) to ensure that the final copy has been accepted by the thesis committee. The TAF must be uploaded as a supplemental file with the thesis in order for the submission to be complete.
- Submit three hard copies of the thesis to the graduate coordinator. Same due date as Graduate School submission date. This version will serve as the archival copy kept by the University Library. These three copies will be bound for students by the department free of charge (one for the student, one for the department and one for the student's advisor).
  - One copy must be printed single-sided, on 8.5" x 11" watermarked paper of at least 25 percent cotton and 20# weight.
  - The other two copies can be printed double-sided, on 8.5" x 11" watermarked paper of at least 25 percent cotton and 20# weight.
- Submit thesis to CU Electronic Scholars Depository (see instructions on the About Institutional Repositories (http://scholar.colorado.edu/about.html) webpage).
- Complete the Survey of Earned Doctorates (contact Graduate Coordinator for details).

Plan of Study

The track below is a sample curriculum for students who are interested in focusing on partial differential equations.

Year One		Credit Hours
APPM 5600	Numerical Analysis 1	3
APPM 5610	Numerical Analysis 2	3
APPM 5470	Methods of Applied Mathematics: Partial Differential and Integral Equations	3

APPM 5460	Methods in Applied Mathematics: Dynamical Systems and Differential Equations	3
	Credit Hours	**12**
Year Two		
APPM 5440	Applied Analysis 1	3
APPM 5450	Applied Analysis 2	3
APPM 5480	Methods of Applied Mathematics: Approximation Methods	3
APPM 5720	Open Topics in Applied Mathematics	1-3
Part 1 of Out of Department Sequence		3
	Credit Hours	**13-15**
Year Three		
Part 2 of Out of Department Sequence		3
APPM 8000	Colloquium in Applied Mathematics	1
APPM 8100	Seminar in Dynamical Systems	1
APPM 7400	Topics in Applied Mathematics	1-3
APPM 6470	Advanced Partial Differential Equations	3
	Credit Hours	**9-11**
Year Four		
APPM 8990	Doctoral Dissertation	10
	Credit Hours	**10**
Year Five		
APPM 8990	Doctoral Dissertation	10
	Credit Hours	**10**
Year Six		
APPM 8990	Doctoral Dissertation	10
	Credit Hours	**10**
	Total Credit Hours	**64-68**

Learning Outcomes

By the completion of our program, students will be able to:

- Become self-directed (independent) learners who can obtain research skills through their own reading, development and research exploration. This outcome should be driven by the student first and foremost rather than by a research supervisor or mentor.
- Demonstrate and exercise technical training in core methods of applied mathematics (including numerical analysis, applied analysis, partial differential equations, statistics and probability) which form the foundation of problem solving in modern research problems.
- Demonstrate and exercise skills in interdisciplinary methods, data science and/or scientific computation in ways that focus on solving important problems in applied mathematics and related fields.
- Successfully design and conduct original research that answers questions of interest to the applied mathematics community and that employs appropriate research methods.
- Effectively communicate and present research to academic and public audiences.
- Demonstrate proficiency and expertise in literature for a relevant area of applied mathematics and synthesize competence in written and oral form.