

INTRODUCTION

The Department of Applied Mathematics of the University of Colorado at Boulder offers a range of courses and research opportunities in several areas including:

- Applied Probability and Statistics
- Computational Mathematics
- Dynamical Systems and Mathematical Biosciences
- Nonlinear Phenomena
- Physical Applied Mathematics

For more information on these areas and research specialties of the department and affiliated faculty, please refer to our website: <http://amath.colorado.edu>.

This document provides information on a variety of topics, ranging from admission procedures to degree requirements. If you have questions that are not answered in this document, please do not hesitate to contact us.

ADMISSION REQUIREMENTS

The admission requirements spelled out below apply equally to the M.S. and Ph.D. programs. The program that the applicant applies for is *not*, in and of itself, a factor in decisions regarding admission or financial support. Applicants should be aware, however, that both programs are competitive, and meeting the requirements does not guarantee admission. Successful applicants will, in general, have records considerably stronger in breadth and quality than these minimum standards suggest.

equivalent from an institution comparable to the University of Colorado in applied mathematics, engineering, mathematics, or a natural science. Those with significant backgrounds in the physical sciences are encouraged to apply. Applicants should have strong foundations in mathematical course work and the mathematical maturity to understand basic concepts in pure and applied mathematics.

mathematical nature beyond calculus, including advanced calculus and linear algebra. Additional recommended courses include partial differential equations, complex analysis, numerical analysis, and perhaps probability and statistics. These courses need not be in a mathematics department; however, they should require the mathematical maturity expected of a strong upper-level mathematics undergraduate.

It is also recommended that applicants have some computing experience. For example, a working knowledge of a scientific programming language such as FORTRAN, C, C++, or MATLAB is recommended, and experience with UNIX can be very helpful.

An exceptional student who has some deficiencies in his/her mathematics background also may be considered for admission. However, such students likely will need to take some upper-division undergraduate mathematics courses during their first year of graduate study. For details, see the **PROVISIONAL ADMISSION** section of this supplement.

APPLICATION DEADLINES

Graduate applications for a given academic year (fall semester admission) should be received from domestic applicants by December 15 of the preceding year and from foreign applicants by December 1 of the

M.S. DEGREE REQUIREMENTS

ACADEMIC ADVISING

Each new student will be assigned a faculty advisor (usually the chair of the graduate committee) for consultation in planning a sound program of study. Advising includes the courses to be taken and the

M.S. candidates must take a yearlong 5000-level graduate sequence outside of Applied Mathematics in an area where mathematics has significant application. This sequence must be approved by the graduate chair. Upon approval by petition to the graduate committee, up to 6 credit hours may be taken in 4000-level courses in other departments, provided members of the graduate faculty teach those courses.

FOREIGN LANGUAGE REQUIREMENT

There is no foreign language requirement for the M.S. program.

GENERAL M.S. DEGREE REQUIREMENTS

The University Catalog provides the general requirements for the degree of Master of Science in all departments of the University of Colorado. The following is a description of the requirements that specifically pertain to students pursuing a course of study leading to the degree of Master of Science in Applied Mathematics. It supplements the requirements outlined in the catalog. In all cases not specifically mentioned below, the general requirements as stated in the catalog apply.

The M.S. degree can serve as a steppingstone for any student considering a Ph.D. program at CU-Boulder or elsewhere. However, the M.S. is unique and an important program in its own right. One of its principal advantages is in preparation for teaching or industry, which is the genesis of the required numerical analysis and out-of-department sequences discussed below. It is also a flexible program in that it supports special interest directions, including the teacher training option listed in the **APPM TEACHER LICENSURE OPTION** section of this supplement.

GRADUATION APPLICATION

Students must complete an online application for graduation whether or not he/she plans to attend commencement. To apply for graduation, log on to myCUinfo.colorado.edu. On the Student tab, select the Apply for Graduation link under Academic Resources. Contact the graduate program assistant for additional information on applying online for graduation.

Students must provide necessary information to the Commencement Office for ordering and shipping the diploma.

A student who does not complete the requirements for graduation for the academic term indicated on the online application must apply online to graduate for the new graduation term.

GRIEVANCE POLICY

If a student feels that he/she has received unfair treatment academically or as a teaching or research assistant, then the student should first attempt to resolve the problem with the faculty member involved. If this fails, the student should speak with the faculty advisor, who will bring the matter before the graduate committee. In the event that the student is dissatisfied with this resolution, he/she may file a written formal complaint with the dean of the Graduate School.

PLAN OPTIONS

The M.S. degree requirements may be fulfilled by following the requirements for either the thesis (Plan I) option or the non-thesis (Plan II) option as described below. See the University Catalog for further details. Students who choose Plan II must obtain approval from the chair of the graduate committee.

Plan I (Thesis option)

A student electing to do a thesis must enroll in 4-6 hours of thesis credit, which count toward the required 30 hours, and must take an oral comprehensive exam (also referred to as a defense) on his/her thesis work. This exam will be administered by a committee consisting of the faculty advisor, who serves as committee chair, and two other faculty members. Each committee member must hold a current graduate faculty appointment. The chair must have a regular graduate faculty appointment, and the remaining committee members must hold either regular or special membership. At least one committee member must hold a regular (tenure or tenure-track) faculty appointment in Applied Mathematics.

The M.S. student on the thesis option must be registered for a minimum of 1 credit hour during the academic term (including summer session) the defense is passed.

At least two weeks before the defense, the M.S. student on the thesis option must submit for approval, a completed M.S. degree audit form, _____ t form (available on the Graduate School website), and the dissertation title and abstract (in electronic format) to the graduate program assistant.

A student who fails the oral thesis defense may, in a later semester, make one and only one more attempt to satisfy this requirement. In doing so, the student may switch from the thesis to the non-thesis option.

An electronic copy of the thesis (in PostScript or PDF format), as well as an unbound copy, printed single-sided on 8.5 x 11 watermarked bond paper of at least 25 percent cotton content and 20-pound weight, should be submitted

Otherwise, the graduate committee may remove an inactive student from the degree program.

TRANSFER CREDIT

Master's degree students may request a maximum of 9 semester hours to be transferred from another institution. All transfer requests must have approval of the graduate committee and the Graduate School.

PH.D. DEGREE REQUIREMENTS

ACADEMIC ADVISING

Each new student will be assigned a faculty advisor (usually the chair of the graduate committee) for consultation in planning a sound program of study. Advising includes the courses to be taken and the areas in which to take the preliminary exams. Incoming students will be prevented from registering until they ob
will assume the duties of the faculty advisor when the committee is formed.

ADEQUATE PROGRESS

Doctoral students must demonstrate adequate progress toward the degree by:

Maintaining a grade point average of the Graduate School minimum of 3.0 or better in all course work

The Graduate School will not accept any grade below B- (2.7) toward the Ph.D. degree.

Attaining either a pass or a research pass on at least one preliminary exam by the conclusion of the first year in the graduate program and passing three prelims, including applied analysis and numerical analysis (attaining at least two research passes), before starting the third year

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Finally, each student must take a yearlong graduate sequence outside of applied mathematics in an area where mathematics has significant application. Faculty advisor approval of this sequence is required.

DISSERTATION CREDIT-HOUR REQUIREMENT

Doctoral students are required to enroll in a minimum of 30 dissertation credit hours to complete the requirements for the Ph.D.

As a rule, no more than 10 dissertation credit hours taken in the semesters prior to the academic term during which the comp

upon meeting this requirement. Extenuating circumstances will be considered by petition to the graduate committee.

Preliminary

At the same time, the Ph.D. student must forward a completed Doctoral Examination Report form, available

The Graduate School will allow Ph.D. students to transfer up to 21 semester hours of course work from another institution toward the doctoral degree. All transfer requests must have the approval of the graduate committee in Applied Mathematics.

Course work already applied toward a graduate degree received from CU-Boulder or another institution cannot be accepted for transfer toward another graduate degree of the same level at CU-Boulder. For
arned by a student cannot be

Credit may not be transferred until the student has completed 6 credits of graduate-level course work as a regular, degree-seeking student on the CU-Boulder campus with a GPA of 3.0 or above.

B.S./M.S. (CONCURRENT) DEGREE PROGRAM

PURPOSE OF THE PROGRAM

This is a five-year degree program leading to both a Bachelor of Science and a Master of Science degree in Applied Mathematics at the conclusion of the fifth year. It enables well-qualified and motivated students to experience graduate-level course work earlier in their education and to obtain an M.S. degree in a reduced time period.

For more information about the B.S./M.S program, consult the Department of Applied Mathematics Undergraduate Curriculum Guide.

COMBINED M.S. AND M.A. PROGRAM WITH MCD BIOLOGY

PURPOSE OF THE PROGRAM

This three-year interdisciplinary program offers two degrees, an M.S. in Applied Mathematics and an M.A. in MCD Biology.

The goal of the program is to produce well-trained applied mathematics students who are capable of making serious contributions leading to advancements in molecular biology. Such students will be well educated in computational sciences, statistics, probability, and molecular biology.

ADMISSION TO THE PROGRAM

Students are expected to meet all requirements for admission to the graduate program in the Department of Applied Mathematics and to possess a basic science background suitable for pursuit of this dual degree. Students also are expected to meet minimum requirements for admission to the graduate program in MCD Biology.

Adequate undergraduate preparation consists of successful completion of basic courses on cell and molecular biology. Any student deemed deficient in either of these areas will be required to take Molecular Cell Biology I and II (MCDB 3135 and MCDB 3145) after enrollment.

Students will be required to apply to both programs, with Applied Mathematics designated as the primary program. Subject to joint recommendation and approval by both programs, incoming students will be admitted to this dual degree program as a regular part of the Applied Mathematics recruitment process.

Interested students should apply to the Applied Mathematics program and indicate their interest in the concurrent degree on their application.

The student will be expected to start both programs simultaneously, except in unusual cases when clearly nothing would be compromised. Continuation of the student beyond the first year is subject to approval by both programs.

CURRICULUM

The required curriculum in Applied Mathematics includes the following seven 3-credit courses: Methods of Applied Mathematics: Partial Differential and Integral Equations (APPM 5470), Numerical Analysis 1 and 2 (APPM 5600 and APPM 5610), Introduction to Mathematical Statistics (APPM 5520), Statistical

Applications: Software and Methods (APPM 5580), Numerical Methods for Unconstrained Optimization (CSCI 6676), and two semesters of Independent Study in Applied Mathematics (APPM 6900).

One semester of APPM 6900 (2 credits) for this program will focus on a basic study of the principles of genetics. The second semester of APPM 6900 (1 credit) will focus on oral student presentations on thesis research, including fielding questions, responding to critiques, and presenting background information. Both sections of APPM 6900 will be arranged in consultation with the student's faculty advisor, who will nominally serve as the course instructor.

This package of 21 credits provides the necessary background in general applied mathematics, computational mathematics, and statistics/probability for students to address challenging problems at the interface of applied mathematics and biology. This preparation is appropriate for either an academic or a commercial setting, especially in the emerging area of bioinformatics.

In MCD Biology, the core curriculum consists of 21 credits as follows. A student takes three 3-credit courses, usually during the second year: Cell Structure and Function (MCDB 5210), Gene Expression (MCDB 5230), and Topics in Developmental Genetics (MCDB 5250). In the third year, a student takes either Molecular Genetics (MCDB 5220) or Cell Signaling and Developmental Regulation (MCDB 5426). In addition, the student takes one 3-credit graduate elective in MCDB and 6 credits of Master's Thesis

APPM 5460 (3 credits)

SOME SAMPLE PROGRAMS

A. Computational Physics, non-

IQ BIO CURRICULUM IN APPLIED MATHEMATICS

IQ Biology students pre-approved by Applied Mathematics may count the IQ Biology Core courses as 12 of the 30 credits required outside Applied Mathematics for the successful completion of the Ph.D.

In addition to Applied Mathematics Ph.D. requirements, the following courses and requirements are mandatory for the Applied Mathematics Ph.D. with a Certificate in IQ Biology:

Year 1:

Quantitative Biology Foundations (IQ Biology Core course, 6 credits)

Statistics and Computations for Genomes and Meta-Genomes (IQ Biology Core course, 3 credits)

Forces in Biology (IQ Biology Core course, 3 credits)

One or two other graduate courses to fill gaps in background related to quantitative biology and pre-approved by the IQ Biology Mentoring Committee

Three 10-week lab rotations with IQ Biology faculty

Years 1-5:

Attend the IQ Biology Seminar and Workshop Series

Year 2:

Start thesis research with IQ Biology faculty in Applied Mathematics (co-advising with mentors outside Applied Mathematics is encouraged), and present at the IQ Biology Symposium. For information about IQ Biology faculty, visit <http://iqbiology.colorado.edu/faculty>.

Years 2-3:

Applied Analysis series (APPM 5440, APPM 5450; 6 credits)

Numerical Analysis series (APPM 5600, APPM 5610; 6 credits)

Probability and Statistics series (APPM 5520, APPM 5560; 6 credits)

One Science Ethics Course (e.g., CHEM 5776; 1 credit)

Years 2-5:

Attend Applied Mathematics colloquia.

Years 3-5:

Participate on the IQ Biology Symposium Organization Committee.

Preliminary Exams:

Pass at least three of the following preliminary exams in Applied Math, with a Ph.D. Research Pass in at least two of them: Applied Analysis, Numerical Analysis, and Probability & Statistics

Comprehensive Exam:

The comprehensive examination must be completed by the end of Year 3.

Dissertation:

Thesis research needs to be carried out with a faculty advisor in Applied Mathematics, and the Ph.D. thesis committee must include at least one other IQ Biology faculty member.

For details on IQ Biology curriculum, visit: <http://iqbiology.colorado.edu/programs/curriculum-overview>.

APPM TEACHER LICENSURE OPTION

Every graduate student in the Department of Applied Mathematics takes a yearlong sequence of courses in some area of application of mathematics. One option is to take this sequence in the School of Education, and ultimately, to both obtain mathematics in a secondary school (i.e., middle through high school). This option is not simple, and pursuing it will delay graduation from the department.

Nevertheless, for graduate students in Applied Mathematics who also seek a teaching license, here are some guidelines.

The Teacher Education Program (TEP) in the School of Education for Secondary Mathematics Teacher Licensure consists of seven courses: (EDUC 3013, EDUC 4023, EDUC 4050, EDUC 4060, EDUC 4232, EDUC 5317, and EDUC 5375), plus one semester of student teaching (which includes EDUC 4513 and EDUC 4712, and is a full-time, full-semester, in-school commitment), and a passing score on the PRAXIS II or PLACE licensure exam in mathematics. Students not yet admitted to TEP are eligible to enroll in EDUC 3013 and EDUC 4050 but must be admitted to take any of the other courses listed above.

Before being admitted to TEP, a student must have met requirements that include a minimum of 56 hours of college work, grade point average minimums (2.75 in several areas, including mathematics courses), 25 hours of youth experience, and a passing score on the PRAXIS II or PLACE licensure exam in mathematics. Prior to student teaching, the student must have completed all but the student teaching semester courses, a series of mathematics requirements, and the PRAXIS II or PLACE Basic Skill Assessment. How much preliminary work will be required depends on details of the student's college background. Interested students should consult with an advisor in the School of Education to learn precise details.

A student interested in pursuing this dual-objective program should plan to complete all of the necessary courses within Applied Mathematics in the first two years. Some of the courses required by the School of Education also may be taken during this time.

With *very* careful planning from the beginning of the Applied Mathematics program, it is possible to complete this dual program within three to three and one-half years. A student following this plan will not necessarily receive financial assistance (a teaching assistantship) from Applied Mathematics after the second year.

Interested students should consult with an advisor in the School of Education for more information.

The Applied Mathematics requirement of a yearlong sequence outside the department may be satisfied by taking EDUC 5317 and EDUC 5375. The other requirements for a Master of Science in Applied Mathematics are found in previous sections of this supplement.

GRADUATE COURSES

Numerous graduate courses in other departments at the University, as well as the University of Colorado at Denver, in essence, are courses in applied mathematics and may be taken for credit toward graduate course

work in Applied Mathematics. In fact, each graduate student must take a yearlong sequence outside the department. Consult a faculty advisor for more information and approval.

BASIC COURSES

Acceptable 5000-level APPM sequences include the following (others require faculty advisor approval): 5430-5470, 5440-5450, 5460-5470, 5470-5480, 5520-5540, 5520-5560, 5600-5610, 5590-5380, 5590-5520, 5590-5540, 5590-5560, and 5590-5580.

The following courses, which are cross-listed as graduate/undergraduate courses, generally **do not** count toward the 30-credit-hour M.S. or Ph.D. requirement:

APPM 5350 (3) Methods in Applied Mathematics: Fourier Series and Boundary Value Problems

APPM 5360 (3) Methods in Applied Mathematics: Complex Variables and Applications

APPM 5570 (3) Statistical Methods

APPM 5720 (3) Open Topics in Applied Mathematics

All of the remaining courses listed below **do** count toward the 30-credit-hour M.S. or Ph.D. requirement:

APPM 5120 (3). Introduction to Operations Research. Studies linear and nonlinear programming, the simplex method, duality, sensitivity, transportation and network flow problems, some constrained and unconstrained optimization theory, and the Kuhn-Tucker conditions, as time permits. Prereqs.: APPM 3310 3963()-159(pr)-6(oblems,)-160(someMAeW*z5 0 0 i(in JIJET3o8.27 T1eW*n)IJJ(0.00000912 0 612 792 r4e2

equivalent to APPM 2360, 3310, and MATH 3001 and MATH 4001. (Normally offered spring semesters of even-numbered years)

~~APPM 5430 (3) Methods of Applied Mathematics: Partial Differential and Integral Equations.~~ Studies properties and solutions of partial differential equations. Covers methods of characteristics, well-posedness, and 4360, or MATH 4430, or equivalent. (Normally offered fall semester)
Prereqs.: APPM 4350

APPM 5480 (3). Methods of Applied Mathematics: Approximation Methods. Covers asymptotic evaluation of integrals (stationary phase and steepest descent), perturbation methods (regular and singular methods, and inner and outer expansions), multiple scale methods, and applications to differential and integral equations. Prereq.: APPM 5470 or instructor consent. (Normally offered spring semesters of odd-numbered years)

APPM 5520 (3). Introduction to Mathematical Statistics. Examines point and confidence interval estimation. Principles of maximum likelihood sufficiency and completeness; tests of simple and composite hypotheses, linear models, and multiple regression analysis. Analyzes variance distribution-free methods. Prereq.: one semester calculus-based probability such as MATH 4510 or APPM 3570. Same as APPM 4520 and MATH 4520/5520. (Normally offered spring and fall semesters)

ADVANCED COURSES

APPM 6470 (3). Advanced Partial Differential Equations. Continuation of APPM 5470. Advanced study of the properties and solutions of elliptic, parabolic, and hyperbolic partial differential equations. Topics include the study of Sobolev spaces and variational methods as they relate to PDEs, and other topics as time permits. Prereq.: APPM 5470. (Normally offered spring semester)

APPM 6520 (3). Mathematical Statistics. Emphasizes mathematical theory of statistics. Topics include distribution theory, estimation and testing of hypotheses, multivariate analysis, and nonparametric inference, all with emphasis on theory. Prereq.: APPM 5520 or MATH 5520. Same as MATH 6520. (Offered on a variable schedule)

APPM 6550 (3). Introduction to Stochastic Processes. Systematic study of Markov chains and some of the simpler Markov processes including renewal theory, limit theorems for Markov chains, branching processes, queuing theory, birth and death processes, and Brownian motion. Applications to physical and

APPM 7900 (1-