GRADUATE HANDBOOK
UNIVERSITY OF COLORADO DENVER
DEPARTMENT OF MATHEMATICAL & STATISTICAL SCIENCES

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CONTENTS

A. DEGREES

The Department of Mathematical & Statistical Sciences at UC Denver offers the *Master of Science (M.S.) in Applied Mathematics* and the *Doctor of Philosophy (PhD) in Applied Mathematics*. These degrees are designed to give candidates a contemporary, in-depth education in applied mathematics and to provide research opportunities in the special fields of computational mathematics, discrete mathematics, mathematics of science and engineering, operations research, optimization, probability and statistics. In addition, a Dual MA/MS degree in Economics and Applied Mathematics (focused in Applied Statistics) is offered.

B. ADMISSION REQUIREMENTS FOR GRADUATE STUDIES IN APPLIED MATHEMATICS

All applicants must establish adequate preparation for graduate studies in Mathematical and Statistical Sciences as demonstrated by at least one of the following:

- A baccalaureate or master's degree (not necessarily in mathematics) from an accredited college or university, or completion of work equivalent to the baccalaureate or master's degree given at CU Denver with at least a 3.0 grade point average (GPA);

or

- Sufficiently high performance on the GRE subject test in mathematics, or completion of at least 12 credit hours of graduate-level mathematical coursework.

In addition, students must have taken a minimum of 30 semester hours of undergraduate mathematics, at least 24 of which are upper division courses with a grade of B– or better. These courses must include

1. one semester of linear algebra
2. one semester of one of the following:
   abstract algebra
   or differential equations
   or discrete mathematics
   or probability
3. two semesters of advanced calculus or real analysis (or equivalent)

Subject to approval by the Graduate Committee, students who do not satisfy all of the above admission requirements may be admitted as a provisional degree student with the understanding that deficiencies must be removed within one year of entry into the program. Undergraduate credits earned for deficiency coursework cannot be applied to a graduate degree.

By University policy, International students must provide financial documentation and certified English translations of all records and references not in English. By graduate school rules, applicants whose native language is not English must satisfy the English language requirement in one of the following ways:

- Submit scores from the Test of English as a Foreign Language (TOEFL, iBT) or from the International English Language Testing System (IELTS). The minimum acceptable scores can be found here English Proficiency Testing.
- Complete a baccalaureate or graduate-level degree at an accredited college or university where the language of instruction and the national language is English.
    - Complete at least 2 semesters (minimum of 30 credits) at an accredited college or university in the United States as a full-time student with a "B" average (3.0 GPA) or higher.

International students are required to submit Graduate Record Examination (GRE) scores. Additional requirements and documentation may also be required by the Office of International Education. For details and procedures, students should consult the Office of International Affairs.

C. TEACHING ASSISTANTSHIPS

The department offers two types of teaching assistantships: full assistantships, which cover student tuition and fees up to a stated credit limit, and partial assistantships, which may consist of a mix of duties, are generally paid hourly or by class assignment, and do not include tuition and fees.

All applicants interested in a teaching assistantship (TA) are encouraged to apply. Outside of exceptional cases, full assistantships are only awarded to students in the doctoral program. Applicants to the M.S. program with a strong interest in teaching may be considered for partial funding depending on the availability of funds. To be considered for a TA, the application packet must be accompanied by a letter indicating interest in a TA and describing prior teaching or tutoring experience. When the Graduate Committee considers requests for TAs, the primary criterion that is used is academic excellence and likelihood of strong academic outcomes while in the program. Other factors that may be considered include ability to teach lower division mathematics courses, quality of faculty recommendations, and outside employment (the candidate cannot be employed off-campus while holding a full assistantship).

Full teaching assistantships are awarded and considered for renewal on an annual basis, and are contingent on (a) satisfactory academic progress within their program of study in the department; (b) sufficient quality of instruction and other assigned teaching duties, and (c) availability of funds. Partial assistantships are considered for renewal each semester, subject to the same criteria, along with availability of appropriate job assignments.

In addition to the renewal criteria outlined above, full TA positions are generally awarded for a maximum of five years of study within the doctoral program and a maximum of two years of study within the M.S. program. Any student requesting funding beyond these time limits must apply to the graduate committee, and should be aware that further funding is not guaranteed.

Provisional students who are offered a TA must reapply for the TA to be continued into a second year of funding. Regular (full-time) TAs in the doctoral program generally do not need to reapply for funding each year, provided they satisfy conditions (a) and (b).

D. ADDITIONAL FACTORS FOR GRADUATE STUDIES IN APPLIED MATHEMATICS

Applicants to the doctoral program with a GPA in mathematics below 3.2 are unlikely to be accepted without strong supporting evidence. Additional factors that can strengthen the application include:

- Strong performance within an MS degree program in Mathematics or related area
- Research activities and experience, including publications in reputable, refereed venues, conference presentations, and/or software development expertise.
- GRE subject test in Mathematics,
- Minor or second major or M.S. in an area related to student's focus,

E. ADMISSION DEADLINES

A complete application packet (including two official transcripts, at least three letters of recommendation, GRE scores, application part I and II, and application fee) should be submitted to the CU Denver Graduate School.

Target Dates for M.S. Program

April 1	for the following fall semester
November 1	for the following spring semester
March 1	for the following summer semester

Target Dates for PhD Program

Outside of exceptional cases, students may only apply to start the PhD program in Applied Mathematics in the Fall Semester.

January 15	for the following fall semester

Applications received after the target dates may still be considered for admission, and possible TA funding, depending on availability.

F. ADVISING

Upon acceptance into the graduate program, each student is assigned an academic advisor. A student may request and obtain a change in academic advisor by informing the Graduate Program Director and Graduate Program Assistant. Students should note that their initially assigned academic advisor will not necessarily be the faculty member who advises their M.S. project or thesis, or their doctoral dissertation. When a student selects a project, thesis or dissertation advisor, henceforth referred to as their "research advisor", they should notify the department so that this faculty member can assume the duties of their academic advisor as well.

A required orientation for all new graduate students is held the week before the fall semester begins. The orientation provides information about the department, the faculty, graduate program requirements, expectations and realities, and an opportunity for students to meet with their academic advisor.

During the first semester of graduate study each student is strongly encouraged to set up a tentative plan of study in consultation with their academic advisor. The plan of study should include a tentative list of courses to be taken each semester. It is also strongly suggested that each student review their plan of study at least once each year with their current academic advisor and discuss any possible course changes.

G. REQUIREMENTS FOR THE M.S. DEGREE

1. General Requirements

Students must complete at least 30 semester hours, of which at least 24 hours must be in mathematics and statistics, numbered 5000 or above. At most six hours may be in courses outside the Department of Mathematical & Statistical Sciences at the 4000 level or above, if approved by the student's academic advisor and by the Graduate Committee. The overall grade point average must be 3.0 or higher. Grades below a B- are not accepted (but they do contribute to the overall GPA).

By graduate school rules, courses taken more than five years prior to applying for candidacy (including transfer courses) must be validated by the graduate program director to ensure their content is still current. However, it is the policy of the Department of Mathematical and Statistical Sciences that the content of all mathematics courses taken at an accredited University is considered current for at least ten years. For courses taken more than ten years prior to applying for candidacy, the validation process will require an assessment of the student's knowledge of the subject matter.

A maximum of 9 credit hours of coursework may be transferred into the M.S. program. Only courses completed with a grade of B- or better may be considered for transfer credit. Credit cannot be transferred until the student has established a satisfactory record of at least six graduate credits in mathematics or statistics at CU Denver with a minimum GPA of 3.0. All transfer courses must be approved by the Graduate Program Director. Courses taken while registered as a nondegree student are considered transfer courses.

By graduate school rules, courses taken while enrolled as a graduate student at any campus of the University of Colorado system is considered resident coursework. In addition, courses taken at other campuses prior to enrollment in the M.S. program will be counted as part of the 9 credit hour limit on transfer courses. Courses taken outside the Department of Mathematical and Statistical Sciences while enrolled in the M.S. program are not guaranteed to count toward the M.S. degree, and it is recommended that they be approved by the Graduate Studies Committee prior to enrollment. The following courses will **not** count toward a graduate degree in applied mathematics: MATH 5000-5010, MATH 5012-5015, MATH 5017, MATH 5198, MATH 5250 and MATH 5830.

2. Math Clinic

All M.S. students are encouraged to participate in at least one Math Clinic (MATH 5779). With the approval of the student's academic advisor, a clinic may be used in lieu of a stated area requirement. Details about current and upcoming projects are available from the Clinic Director.

3. Advisory Committee

By the end of the first year of graduate study, each student must choose a research advisor to chair their advisory committee. With this advisor's help, the student will choose two additional members of the advisory committee. All three members must be on the CU Denver Graduate Faculty, and at least two must be members of the Department of Mathematical & Statistical Sciences.

4. Thesis Option

Each student has the option to write a thesis to which 4-6 of the 30 hours of course work may be devoted. Although original work is encouraged, the thesis may be expository in nature. The topic should be within a relevant area of Applied Mathematics and should be chosen with the approval of the research advisor. The thesis must comply with university formatting guidelines and meet all relevant deadlines as put forth each semester by the Graduate School. A typed copy of the thesis must be given to all members of the advisory committee at least three weeks before the defense. The student must provide a single .pdf file of the thesis with an attached statement giving the Department the right to distribute the thesis as it wishes.

5. Final Examination

All students must take and pass a final examination. The exam is given by the student's advisory committee.

For students choosing the thesis option, the exam consists of a one-hour thesis defense. The advisory committee may declare the thesis defense successful, but request further changes in the thesis and specify a deadline and the manner in which the revised thesis will be reviewed. In that case, the student does not need to register for further thesis credit hours, but the requirements for the master's degree are not satisfied until the final version of the thesis is approved by the student's advisory committee and the Graduate School. If no member of the advisory committee raises further questions or objections within 30 days after the revised thesis has been received by the committee, the thesis is considered approved.

Students choosing the non-thesis option will submit a written report, give an oral presentation and answer questions on a relatively specific topic that has been selected in consultation with their research advisor and has been approved by the student's advisory committee. The report and presentation should demonstrate a level of content mastery commensurate with a 6000 level mathematics course, delve into mathematics not covered in coursework, and should demonstrate proficiency in communicating mathematics as well as the ability to synthesize mathematical concepts. The written report should be submitted to the advisory committee at least two weeks prior to the oral presentation. Students completing a master's degree while pursuing a PhD degree are encouraged to choose a topic that may complement their PhD research.

By graduate school rules: “A student who fails the examination is subject to immediate dismissal from the Program on the recommendation of the Graduate Program Director and concurrence of the Dean. At the Program’s discretion, a student who fails the examination may be allowed to retake the exam. The re-examination must be completed by the end of the next academic semester (excluding Summer). The original examination form noting the failure is signed by the committee and returned to the Graduate School office. New examination forms will be generated when the examination is rescheduled. The student will be required to meet registration requirements and be registered during the semester in which the repeated exam is taken.”

6. Time Limits for Completion of Degree

By graduate school rules, Master's degree students have five years from the date of admission to complete all degree requirements.

7. Leave of Absence

A student may request up to a one-year leave of absence from the M.S. program. The student must be in good standing, indicate the return date, give justification for the leave of absence, and agree to contact his/her academic advisor and the Graduate Committee at least once per semester. Each petition must be approved by the Graduate Program Director.

A leave of absence does not extend deadlines automatically; extension of deadlines requires a separate petition to the Graduate Committee. Students who leave a graduate program for more than three consecutive semesters will be removed from that program, and must reapply for readmission through the Graduate School here.

8. Course Requirements

The following course requirements must be satisfied by all M.S. students:

1. *(Analysis Core Requirement)* One of: MATH 5070 (Applied Analysis) or MATH 6131 (Real Analysis),
2. *(Linear Algebra Core Requirement)* MATH 5718 (Applied Linear Algebra), and
3. At least 24 additional semester hours of coursework, subject to the rule about 4000-level courses in disciplines outside of mathematics outlined above.

Additionally a student must either satisfy the course requirements for the M.S. degree without a concentration area or satisfy the requirements in one of the concentration areas listed below. Unless noted elsewhere, one course cannot be used to fulfill two requirements.

Substitutions or changes to the requirements may be made with the written approval of a student’s academic advisor and the Graduate Committee.

Course Requirements for the M.S. Degree without a Concentration Area

Students must complete at least three courses chosen from the following list. Note that MATH 6131 (Real Analysis) can be used to satisfy both the analysis core requirement and may also count as one of the three courses satisfying this requirement.

Any MATH course at the 6000 level or above
MATH 5135 Functions of a Complex Variable
MATH 5310 Probability
MATH 5320 Introduction to Mathematical Statistics
MATH 5350 Mathematical Theory of Interest
MATH 5351 Actuarial Models
MATH 5410 Modern Cryptography
MATH 5432 Computational Graph Theory
MATH 5446 Automata Theory
MATH 5490 Network Flows
MATH 5593 Linear Programming
MATH 5610 Computational Biology

Additional course options may be added later at the discretion of the Department of Mathematical and Statistical Sciences, e.g., as new courses are introduced to the graduate program.

Concentration Area Requirements:

a. Applied Statistics
MATH 5310 Probability
MATH 5320 Introduction to Mathematical Statistics
MATH 5387 Applied Regression Analysis
MATH 6330 Workshop in Statistics Consulting (Can be taken more than once.)
MATH 6388 Advanced Statistical Methods for Research

b. Applied Probability

MATH 5310 Probability
MATH 5792 Probabilistic Modeling
MATH 6380 Stochastic Processes

And, one of the following two courses:

MATH 6131 Real Analysis
MATH 7381 Mathematical Statistics I

c. Discrete Mathematics

Four of the following twelve courses:

MATH 5410 Modern Cryptology
MATH 5490 Network Flows
MATH 5793 Discrete Math Modeling
MATH 6404 Applied Graph Theory
MATH 7405 Advanced Graph Theory
MATH 7409 Applied Combinatorics
MATH 7419 Mathematical Coding Theory
MATH 7410 Combinatorial Structures

MATH 7413 Modern Algebra I
MATH 7421 Projective Geometry
MATH 7821 Topics in Projective Geometry
MATH 7823 Topics in Discrete Math

d. Mathematics of Engineering and Science

Three of the following seven courses:

MATH 5387 Applied Regression Analysis
MATH 5779 Math Clinic
MATH 5791 Continuous Modeling
MATH 5792 Probabilistic Modeling
MATH 5793 Discrete Math Modeling
MATH 5794 Optimization Modeling
MATH 6735 Continuum Mechanics

And, two of the following six courses:

MATH 5660 Numerical Analysis I
MATH 5661 Numerical Analysis II
MATH 5733 Partial Differential Equations
MATH 6653 Intro to Finite Element Methods
MATH 7663 Finite Difference Methods for PDEs
MATH 7665 Numerical Linear Algebra

e. Numerical Analysis

MATH 5660 Numerical Analysis I
MATH 5661 Numerical Analysis II

And, three of the following ten courses:

MATH 5593 Linear Programming
MATH 5733 Partial Differential Equations
MATH 6595 Computational Methods in Nonlinear Programming
MATH 6653 Intro to Finite Element Methods, formerly MATH 7172
MATH 6735 Continuum Mechanics
MATH 7667 Intro to Approximation Theory
MATH 7663 Finite Difference Methods for PDEs
MATH 7665 Numerical Linear Algebra
MATH 8664 Iterative Methods in Numerical Linear Algebra
MATH 8660 Math Foundations of Finite Element Methods

f. Operations Research

MATH 5593 Linear Programming
MATH 5792 Probabilistic Modeling or MATH 6380 Stochastic Processes

And, two of the following courses:

MATH 5390 Game Theory
MATH 5490 Network Flows
MATH 5779 Math Clinic, with approval
MATH 5794 Optimization Modeling
MATH 6595 Computational Methods in Nonlinear Programming
MATH 7825 Topics in Optimization
MATH 7593 Advanced Linear Programming
MATH 7594 Integer Programming
MATH 7595 Advanced Nonlinear Programming

H. REQUIREMENTS FOR THE DUAL M.A./M.S. IN ECONOMICS AND APPLIED MATHEMATICS

1. Overview

A "dual" degree means that students who complete the program earn two master's degrees: M.A. in economics and M.S. in applied mathematics. Students interested in completing the dual degree in economics and applied mathematics must apply separately to each program, meet the admission requirements of each program, and be accepted by each program. If one program accepts a student for the dual degree but the other program does not, then the student may not graduate under the dual degree program. Students may apply to both programs at the same time or apply to the economics program first, and then to the applied math program after their first semester, or vice versa. Both programs must be completed in the same semester to take advantage of the dual degree program.

2. Degree Requirements

The requirements for the dual degree in economics and applied mathematics include completing 21 credit hours in ECON and 21 credit hours in MATH (42 total credit hours). Students are expected to meet all course prerequisites. ECON 5803 – Mathematical Economics is a prerequisite for ECON 5073 - Microeconomic Theory and ECON 5813 - Econometrics I. This prerequisite requirement is waived for students who are currently admitted to the MS Applied Mathematics program.

A grade of B- or better is required in all courses, with a cumulative grade point average of B (3.0) or above. No course may be taken more than twice.

3. Core Courses

The following 12 courses (36 hours) are required of all dual degree students.

ECON 5073 - Microeconomic Theory
ECON 5083 - Macroeconomic Theory
ECON 5813 - Econometrics I
ECON 5823 - Econometrics II
ECON 6053 - Seminar in Applied Economics
ECON 6054 - Seminar in Applied Economics II
MATH 5070 - Applied Analysis

MATH 5718 - Applied Linear Algebra
MATH 6330 - Workshop in Statistical Consulting
MATH 6388 - Advanced Statistical Methods for Research
MATH 7381 - Mathematical Statistics I
MATH 7382 - Mathematical Statistics II
ECON 6073 - Research Seminar

4. Electives

Dual degree students must also choose two elective courses, according to the following guidelines.

One 5000 or higher course with a MATH prefix **(3 semester hours)**, except MATH 5000-5010, MATH 5017, MATH 5198, MATH 5250 and MATH 5830.

One 5000 or higher course with an ECON prefix **(3 semester hours)**.

Contact a graduate advisor in the Economics Department for information about Econ course requirements.

I. REQUIREMENTS FOR THE PHD DEGREE

1. Graduation Requirements

There are six requirements for the successful completion of the PhD program. A candidate must (1) fulfill course requirements, (2) pass the preliminary examinations, (3) meet the academic residency and participation requirements, (4) pass the comprehensive examination, (5) give an oral thesis proposal, and thereafter meet every year with his/her PhD advisory committee and (6) write and defend a thesis.

2. Course Requirements

PhD students must complete 42 credit hours of non-dissertation graduate courses. The following courses will **not** count toward a graduate degree in applied mathematics: MATH 5000-5010, MATH 5012-5015, MATH 5017, MATH 5198, MATH 5250 and MATH 5830. By graduate school rules, courses taken more than five years prior to applying for candidacy (including transfer courses) must be validated by the graduate program director to ensure their content is still current. For mathematics courses taken within ten years of applying for candidacy, the validation request will be automatically approved. For courses taken more than ten years prior to applying for candidacy, the validation process will require an assessment of the student's knowledge of the subject matter.

The following courses are required as a part of the formal course work:

- Math Clinic (MATH 5779) (3 hours)
- 3 Readings Courses (MATH 7921-7926) (1 credit hour each.)

The Readings Courses are one-hour seminar courses that are announced prior to the start of each semester. As discussed in section F, all courses, including readings courses, should be

chosen in consultation with an academic advisor. Course replacements and equivalencies must be approved by the Graduate Committee.

Within the coursework requirement, students must satisfy a breadth requirement by completing six graduate math courses from the following categories. No more than three of these courses can come from any one category:

1. Computational Mathematics
2. Discrete Mathematics
3. Operations Research (including Probability)
4. Statistics
5. General

A list of which courses are included in each of the areas is available on the Department web page. (See Graduate Courses by Area). The breadth courses must be formal courses excluding MATH 5070 (Applied Analysis), MATH 5718 (Applied Linear Algebra), MATH 5779 (Math Clinic), readings courses, and independent studies. Transfer courses and/or courses earned at another campus of the University of Colorado system may be used to satisfy this requirement, with approval of the Graduate Program Director.

A maximum of 30 credit hours of graduate coursework (including courses applied to a Master's degree), may be transferred into the PhD program. Up to 6 credit hours of this 30 may be awarded for a Master's thesis. Only graduate courses completed with a grade of B- or better may be considered for transfer credit. Credit cannot be transferred until the student has established a satisfactory record of at least 12 graduate credits in mathematics or statistics at CU Denver with a minimum GPA of 3.0. All transfer courses must be approved by the Graduate Committee. Courses taken while registered as a nondegree student are considered transfer courses. By graduate school rules, courses taken while enrolled as a graduate student at any campus of the University of Colorado system is considered resident coursework. However, all courses taken outside of the Department of Mathematical and Statistical Sciences must be approved by the Graduate Committee to be applied toward the PhD In addition, courses taken at other campuses prior to enrollment in the PhD program will be counted as part of the 30 credit hour limit on transfer courses. Courses taken outside the Department of Mathematical and Statistical Sciences while enrolled in the PhD program are not guaranteed to count toward the PhD degree, and it is recommended that they be approved by the Graduate Studies Committee prior to enrollment.

All PhD course work must be completed with at least a 3.25 grade point average. Grades below a B- are not acceptable for the PhD. A student who receives a grade of C+ or lower, or whose overall GPA as a doctoral student falls below 3.25 will be reviewed by the Graduate Committee and may be put on probation or suspended.

3. Preliminary examinations

Each student must pass two preliminary exams: one in Applied Analysis and one in Applied Linear Algebra. These are four-hour written exams that cover material roughly at the level of first-year graduate study. The exams are each four hours in duration, and are offered twice per year. The first offering each year is in January, generally one week apart, on or about the week prior to the start of the spring semester and the first week of the spring semester. The second

exam offerings occur each summer, generally on or about the 15th of June, and on or about the 15th of July.

A student wishing to take a preliminary exam must sign up with the graduate program assistant at least one month prior to the administration of the exam. Students who cannot take the exam as planned should give notice of withdrawal at least one week prior to the exam.

Timeline: PhD students must pass both preliminary exams by the beginning of their fourth semester in the PhD program. For the purposes of this rule, a winter preliminary examination offered in the first week of a student's fourth semester of the PhD program is considered as being offered prior to the start of their fourth semester. If a student fails to meet this deadline, s/he may petition the Graduate Committee in writing for a one semester extension. The petition will be successful only if the student's overall record indicates their having skills and potential for completing the PhD. If a student fails to meet the deadline and is denied another attempt, the student will be dismissed from the PhD program at the conclusion of their fourth semester, but may remain in the MS program. An MS student or an applicant to the PhD program may attempt each preliminary exam at most once prior to matriculating into the PhD program.

4. PhD Advisory Committee

Each student must choose a research advisor and, with this advisor's help, select other members of the PhD advisory committee. This committee assumes the dual responsibility for advising and testing the student. In particular, under the direction of their research advisor, each member of this committee will:

1. Design and evaluate the Comprehensive Exam;
2. Advise on research and serve as the examining committee for the student's dissertation defense.

The PhD advisory committee consists of five Regular or Special members of the CU Denver Graduate Faculty, one of whom is the student's research advisor. At least one committee member must have their primary and prior affiliations outside of the Department of Mathematical & Statistical Sciences. At least three committee members will be regular faculty members of the Department of Mathematical & Statistical Sciences. Exceptions to this must be approved by the Graduate Committee. Committee members may be from outside the CU system, but must be granted special membership on the CU Denver graduate faculty for this purpose. The chair of the PhD advisory committee must be a regular faculty member of the Department of Mathematical & Statistical Sciences. The primary purpose of the committee chair is to ensure unbiased evaluation of the student's work. Hence, the research advisor cannot be the chair of the committee. In addition, the chair will ensure that all administrative requirements are followed. The research advisor must be a Regular Member of the CU Denver Graduate School.

The research advisor must seek and have received approval from the Graduate Committee for the composition of the advisory committee at least 30 days before the student takes the comprehensive exam. After formation the chair, advisor or student may petition for changes to the committee membership; however, approval must be provided by the Graduate Committee at least 30 days before the date of the thesis defense. No changes to the PhD advisory

committee will be allowed during the 30 days prior to the comprehensive exam and until the conclusion of the comprehensive exam. Similarly, no changes to the PhD advisory committee will be allowed during the 30 days prior to the thesis proposal and thesis defense.

After the student has been admitted to candidacy and has presented the research proposal, the advisory committee will meet with the student at least once per year to assess progress. Written records of the advisory committee meetings and the student's progress must be kept in the student's file. Students who have not had an advisory committee meeting for the previous 12 months will not be allowed to register. If progress is unsatisfactory, the committee will write a written report to the student and the graduate program director specifying steps to be taken to rectify the situation. If the student does not achieve an acceptable level of progress within six months after receipt of this report, the student will be terminated from the program. A thesis defense is scheduled upon recommendation of the PhD advisory committee.

5. Residency and Participation

By Graduate School rules, all doctoral students must be enrolled for a minimum of six (6) semesters of full time scholarly work beyond the attainment of a bachelor's degree. Two of these six semesters may be replaced by a master's degree in mathematics from another institution; however, at least four (4) semesters of credit must be earned for work performed while enrolled at CU Denver. For this purpose a full course load is defined to be five semester hours of course work.

PhD students are expected to participate in the life of the department by attending colloquia, seminars, orientations and other department activities and by spending time on campus interacting with other students and faculty outside of normal class hours. Students should discuss with their academic advisors how to fulfill the spirit of this requirement.

6. Comprehensive Examination:

Timeline and Requirements: Students must complete their comprehensive examination prior to the start of their fourth year in the PhD program. Students must have completed at least 36 credits of non-thesis coursework by the end of the semester in which they attempt their comprehensive exam.

Applying for Candidacy: Application for candidacy to the PhD program must be made at least two weeks before the comprehensive examination is taken. Candidacy will be granted after at least three semesters of residence have been earned, an advisory committee has been selected, all preliminary examinations have been passed, and essentially all course requirements (including the breadth requirement) have been satisfied. Any student who has not completed the required 42 credits of non-thesis coursework at the time of their application for candidacy should list all intended coursework on their application for candidacy as "to be completed".

Objectives and Format: The comprehensive exam has the following objectives: to determine mastery of graduate level mathematics, capacity to synthesize mathematical concepts, and ability to embark upon doctoral thesis research. The comprehensive exam has two parts:

1. The first part consists of a written exam of roughly (but not limited to) six hours. The written exam covers material from the student's intended area of research. The choice of area and the extent of coverage within that area will be determined by the student's advisory committee. The advisory committee will prepare and conduct the exam and determine the outcome.

2. The second part of the exam consists of an oral follow-up, not to exceed two hours in length. The student will be given a copy of the scored written exam, no later than seven days after that exam, and a list of topics in which the committee found the student deficient. The oral follow-up will cover but need not be limited to questions on the written exam and topics on the list provided to the student. The oral exam is open to the faculty of the Department of Mathematical and Statistical Sciences and must be scheduled and advertised to all department faculty at least two weeks prior to the exam. The oral should be given within four weeks of returning the graded exam to the student.

The committee decides by majority vote on one of the possible outcomes of the comprehensive exam: pass, conditional pass, or failure. If a student receives a conditional pass, the committee will clearly define the requirements for the student to receive an unconditional passing grade and these requirements must be completed to the satisfaction of the examination committee within four months. In the event of failure of the comprehensive exam, the student's advisory committee will determine the next step (dismissal from the program, retake of the oral follow-up and/or a retake of the written exam are possible outcomes). If a retake is allowed, the retake must be completed within 12 months. The Graduate Committee will hear grievances and appeals of the outcome of the comprehensive exam.

All members of the advisory committee must be present for the oral exam; however, a minority of members, but not the chairperson nor the student, may participate by interactive video. In the event of an emergency that prevents one committee member from attending the exam, the exam can proceed with the faculty who can attend. However, the student will need to meet with the absent committee member at an alternate time.

Admission to candidacy follows successful completion of the two parts of the comprehensive exam.

7. Thesis Proposal

Timeline: Within six months of successful completion of the written exam and/or oral follow-up, the student must give complete an oral research proposal before the advisory committee. At least two weeks prior to the oral proposal, the student must submit a written proposal as outlined below.

Format: The goal of the thesis proposal is for the student to articulate their intended dissertation research, both in writing and orally, and to receive guidance from the advisory committee on the feasibility and impact of the proposed research.

The thesis proposal has two parts:

1. The student must complete a written research proposal of at most 15 pages that addresses the following:

a. A description of the student's proposed research problems.
b. A thorough review of the relevant literature.
c. A detailed description of possible methodologies that could be used to approach the proposed research.
d. A discussion of how the student plans to approach each of their proposed research problems in light of the literature review and methodologies discussed above.

After completing the oral research proposal, the student will be asked to submit a final written proposal that reflects any recommendations made by the advisory committee.

2. An oral research proposal that covers the main parts of the written proposal. The purpose of this presentation is to determine the feasibility of the student's proposed thesis topic. The research proposal is open to the public and must be scheduled and advertised through the graduate program assistant at least two weeks prior to the presentation. The student will be provided a detailed summary of the committee's assessment and recommendations, which (as above) should be incorporated into a revised version of the student's written proposal. At the discretion of the advisory committee, a student may be asked to give a subsequent oral proposal at a later date.

8. Thesis

Each student must complete at least 30 hours of thesis credit. Not more than 10 of these hours may be taken in any one semester. Not more than 10 thesis hours taken prior to the semester of the comprehensive examination may be applied to this requirement.
Candidates for the PhD degree are required to write a dissertation containing original contributions and evidence of significant scholarship. The thesis is written under the guidance of the student's research advisor, who is a Regular Member of the Graduate School, or a secondary research advisor. The thesis must comply in format with the specifications of the Graduate School and must be prepared in TeX, LaTeX, AMSTeX or MSWord (see CLAS thesis guidelines). Six weeks before the date of graduation, the Graduate School must be notified by the candidate of the dissertation title. Thirty days before the final thesis defense, the thesis must be available in written form. Eighteen days before the date of graduation, three complete copies of the thesis must be filed with the Graduate School. The student must provide the Department with a .pdf file of the thesis with an attached statement giving the Department the right to distribute the thesis.

At least thirty days before the date of graduation, the candidate must present and defend the dissertation before the student's advisory committee. The defense is open to the public and must be scheduled and announced at least two weeks prior to the exam to the graduate school and on the department website. All members of the advisory committee must be present for the defense; however, a minority of members, but not the chairperson nor the student, may participate by interactive video. In the event of an emergency that prevents one committee member from attending the exam, the exam can proceed with the faculty who can attend. However, the student will need to meet with the absent committee member at an alternate time. The outcome of the defense can be "pass", "conditional pass", or "fail", as determined by a strict majority vote of the committee. If the student receives a conditional pass, the examining committee will define requirements that the student must satisfy to pass the defense. These requirements must be completed to the satisfaction of the committee within 60

days. Any extensions to this deadline requires a recommendation from the Graduate Committee and approval by the graduate school.

The committee may declare the thesis defense successful, but may request further minor changes in the thesis and specify a deadline and the manner in which the revised thesis will be reviewed. In that case, the student does not need to register for additional thesis hours, but the requirements for the PhD are not satisfied until the final version of the thesis is approved by the advisory committee and the Graduate School. If no member of the committee raises further questions or objections within 30 days after the revised thesis has been received by the research advisor, the thesis will be considered approved by the advisory committee.

In the event of failure, by graduate school rules, the student will be dismissed from the program. Any exceptions to this will require approval from the Dean of the Graduate School.

9. Language Requirement

The University of Colorado permits each department to decide whether or not to implement a foreign language requirement. The Department of Mathematical & Statistical Sciences has approved the following policy:

Recognizing that the need for a foreign language to do research varies from no languages in many areas to one or two languages in a few areas, the department has no formal language requirement. Instead, the necessity for some level of proficiency in a foreign language is left to the discretion of each student's research advisor, as is the case for other matters related to a student's preparation for research.

10. Time Limits

PhD students must pass both preliminary exams by the beginning of their fourth semester in the program. If a student fails to meet this deadline, s/he may petition the Graduate Committee in writing for a one semester extension. The petition will be successful only if the student's overall record indicates their having skills and potential for completing the PhD. If a student fails to meet the deadline and is denied another attempt, the student will be dismissed from the PhD program, but may remain in the MS program. An MS student or an applicant to the PhD program may attempt each preliminary exam at most once prior to matriculating into the PhD program.

Students should begin the process of selecting a research advisor and a PhD advisory committee by the end of the semester in which all preliminary exams have been passed and must select a research advisor and form a PhD advisory committee prior to the start of their third year in the program. Students must pass the comprehensive examination by the start of the fourth year in the PhD program. All requirements for the PhD degree must be completed within five years of passing the comprehensive examination and within eight years of entering the PhD program.

It is recognized that flexibility is necessary, especially for transfer and part-time students; hence petitions for exceptions will be considered by the Graduate Committee. The three-year deadline for passing the comprehensive exam and the eight-year deadline for completing the PhD is imposed by the Graduate School and exceptions require approval of the Dean of the Graduate School.

11. Leave of Absence

A student may request up to a one-year leave of absence from the PhD program. The student must be in good standing, indicate the return date, give justification for the leave of absence, and agree to contact his/her academic advisor and the Graduate Committee at least once per semester. Each petition must be approved by the Graduate Program Director.

A leave of absence does not extend deadlines automatically; extension of deadlines requires a separate petition to the Graduate Committee. Students who leave a graduate program for more than three consecutive semesters will be removed from that program, and must reapply for readmission through the Graduate School here.

J. Transitional Rules

All current MS and PhD students have the option of graduating under the current rules or under the rules in effect when they were admitted, unless otherwise noted above, except that changes that are the consequence of an external entity (such as accreditation) apply to all students. See the Graduate Handbook Archive for earlier versions of the rules.

K. Exceptions

Unless otherwise stated, exceptions to these rules must be approved by the Graduate Committee. In cases where an exception can be made while still satisfying all requirements of the graduate school, the Graduate Committee may approve the request with consultation of the student's advisory committee. In cases involving exceptions to graduate school rules, the Graduate Committee, if it approves the exception, will submit a petition to the graduate school, which will then either approve or deny the exception.