UNIVERSITY OF DELAWARE

GRADUATE STUDENT HANDBOOK

DEPARTMENT
OF
MATHEMATICAL SCIENCES

2023-2024

Graduate Programs in the Department of Mathematical Sciences

Last updated and approved by the faculty: April 2023

Table of Contents

1. History and Overview

Mathematics was present at the University of Delaware from the start. The founder of the university, Francis Alison, wrote of his new school in 1768, "The Languages are carefully taught, along with arithmetic, geometry, practical branches of mathematics, and logic." By 1773, the fledgling academy employed two professors--a philosopher and a mathematician. By 1826, the department structure had arrived at U.D., with a separate room set aside for a "Mathematical and English Department." In 1832, mathematics became part of a new department of "Mathematics and the Natural Sciences." Over the next century, both the university and the department underwent significant growth, but it wasn't until the late 1950's that doctoral programs were established at the University of Delaware. In 1965, the Department of Mathematical Sciences created the seventh doctoral program hosted by the university. By 1969, the department had awarded its first Ph.D. degree.

Over the last forty years, well over one hundred students have received doctoral degrees in Mathematics or Applied Mathematics from the University of Delaware. Graduates from our program have gone on to prestigious postdoctoral positions at institutions such as Oxford University, the University of Arizona, California Institute of Technology, and the University of Minnesota. They hold or have held academic positions worldwide and they work in industry, commerce, and government, at organizations such as DuPont, Amazon, and the National Security Agency. Today, with active research groups in numerous areas of pure and applied mathematics, the department continues to train high-quality mathematics researchers destined to impact the future of mathematics and its applications worldwide.

The Department of Mathematical Sciences offers programs of study leading to Master of Science (M.S.) and Doctor of Philosophy (Ph.D.) degrees in Applied Mathematics and in Mathematics. The department also offers a 4+1 BS/MS program allowing students to complete both a Bachelor of Science and Master of Science degree in five years of full-time study. Requirements for the degrees in the various programs are detailed in Section 3. Many areas of mathematics and its applications are included among the research interests of the faculty of the department. The department offers a wide range of regularly scheduled seminars and colloquia, including the Hallenbeck Graduate Student Seminar, Rees Distinguished Lectures, and numerous seminar series organized by the faculty around research interests in the department. Students should attend the Graduate Student Seminar each week and departmental colloquia, in addition to sampling other available seminars during their first year. By the second year of study, doctoral students should have become a regular attendee at one or more research-oriented department seminars.

2. Admission

Admission to the graduate programs in Applied Mathematics and Mathematics is open to students who have completed the equivalent of a baccalaureate degree in mathematics or related fields, and who have a sound preparation in linear algebra and advanced calculus. On a 4.0 system, applicants should have a GPA of at least 2.5 and an average of at least 3.0 in mathematics and related areas. Applicants who have completed an advanced degree must have done so with a GPA of at least 3.0. In addition, applicants must take the GRE General Test and one GRE Subject Test. It is not required that the GRE Subject Test be in mathematics.

To be eligible for admission, students from a country where English is not a primary language must demonstrate proficiency in English by meeting at least one of the following criteria:

- Score at least 600 on the paper-based TOEFL exam.
- Score at least 100 on the TOEFL iBT, with a minimum score of 20 in each section.
- Score at least 7.5 on the IELTS with a minimum score of 6.0 in each subsection.

Admission to the graduate program is competitive. Those who meet stated requirements are not guaranteed admission, nor are those who fail to meet all of those requirements necessarily precluded from admission if they offer other appropriate strengths.

Students who wish to be admitted to the 4+1 B.S./M.S. program should submit an application during their junior year of academic study toward an undergraduate degree at the University of Delaware. Such students must be enrolled in a Bachelor of Science degree program administered by the Department of Mathematical Sciences. At a minimum, the applicant must have a cumulative GPA of 3.2 and a GPA of 3.4 in their undergraduate major. The applicant must have completed at least two mathematics courses at or above the 400 level. Two letters of recommendation from University of Delaware faculty and academic transcripts must be submitted. Neither the GRE nor the TOEFL exam is required. Meeting minimum requirements is not a guarantee of admission. Similarly, those who fail to meet minimum requirements are not precluded admission if they offer other appropriate strengths.

3. Academic Regulations

The authority for administering the program rests with the Graduate Studies Committee. The Director of Graduate Studies serves as the academic advisor to all students until such time as a supervisor for the thesis or dissertation is selected. New students, as part of the orientation program, will meet with the Director of Graduate Studies to plan their first year of study in the program.

Before each semester, students must obtain their advisor's permission to register for courses. During advisement, they will be given help with course selection based on their interests and record. The department is committed to providing individualized attention and guidance to every student in the program. For concerns, questions, or difficulties, students are encouraged to meet with the Director.

In making their plan of study, students should pay particular attention to the timing of course offerings and their background and interests. It is not unusual that students may want to change their plan as their experience in the department grows. Nevertheless, having even a tentative plan will serve to ensure a timely completion of goals. M. S. and Ph. D. students should consult Sections 3.1.3 and 3.2.6 regularly to ensure that they continue to make satisfactory progress.

Transfer of credit from other U.S. institutions is available only for courses at the graduate level that have not counted towards the requirements of any other academic degree. Permission is required from the student's advisor and the Chair of the department. A form and instructions are available from the website of the Graduate College. Transfers of credit should be requested in a timely manner so that the student's plan of study is clear. Transfer of credit from non-U.S. institutions is generally not possible.

3.1 Degree Requirements for the M.S. in Mathematics and Applied Mathematics

The M.S. degree in Mathematics or Applied Mathematics can be earned through one of two options: 30 credits of graduate level coursework; or 24 credits of graduate level coursework and 6 credits for research and thesis in the final semester. The Master's thesis must be successfully completed and defended.

3.1.1. Coursework

To be eligible for the degree, an M.S. candidate (including 4+1 B.S./M.S. students) must complete 30 credits of course work beyond the Bachelor's degree. These credits can come from the following sources:

- Any 600 or 800 level MATH course listed in section 3.2.3, for a minimum of 24 credits (or 18 credits for students who select the thesis option)
- Any 600 or 800 level non-MATH course, up to a maximum of 3 credits
- The reading course MATH 870, up to a maximum of 3 credits

For students who select the thesis option for the M. S., their 30 credit total must include:

- 6 credits of MATH 869 ("Master's Thesis")

The Master's thesis must be successfully defended (see Section 3.1.2). One or more of the requirements above may be waived upon petitioning the Graduate Studies Committee. Credit hours for which the grade is below C-minus do not count toward a graduate degree.

Students in the 4+1 B.S./M.S. program may count up to six credits of coursework toward both their B.S. and M.S. degrees. This coursework must consist of MATH 600 level classes or above, and not otherwise be restricted by the catalog.

3.1.2. Thesis Option

The purpose of this option is to assess the student's ability to conduct and report original research on a particular area within the field of specialization and/or synthesize and critically analyze important issues in the field of specialization. The particular form of the thesis project (e.g., report of original research or critical review of and exposition on the literature) will be determined by the student in consultation with his or her thesis advisor and the Thesis Committee.

The Thesis Committee shall consist of three faculty and is chaired by the advisor. It is not required that a member of this committee be from outside the department. After the topic(s) and project format have been determined, the student will have a maximum of one year to complete the written thesis (typically 50 to 60 pages).

The student is responsible for following the Graduate College deadlines and procedures relating to the thesis, defense, and application for the degree. An oral defense will be scheduled following the Thesis

Committee's evaluation of the thesis. This defense will be open to the academic community.

3.1.3. Timetable and satisfactory progress

All students are subject to the regulations of the Graduate College. The Graduate College sets specific policies regarding probationary status and satisfactory progress. In particular, a student must maintain a cumulative GPA of 3.0 or better or risk dismissal. A student must have a cumulative GPA of 3.0 or better in order to receive a graduate degree.

The Graduate College requires *six* credits of graded coursework per semester to be registered as a full-time student funded on a Teaching Assistantship (TA), Research Assistantship (RA) or Graduate Assistantship (GA). This applies to all students, whether domestic or international. However, many students in the Department of Mathematical Sciences take nine credits in addition to their TA, RA or GA duties and/or training. *Nine* graduate credits or sustaining in the fall and spring semesters is the minimum registration requirement to be classified as a full-time for students who are self-funded or receive a fellowship.

In addition to Graduate College regulations, the following regulations are specific to the Department of Mathematical Sciences for students receiving financial support through GA, RA, TA, or departmental/university fellowships. Except where noted otherwise, students seeking a waiver of any these regulations must petition the Graduate Studies Committee

1. No more than nine credits of graded coursework may be taken without the permission of the Graduate Director. Students are permitted to register as "listener" for up to three credits beyond the nine graded credits.

2. Unless approved by the Graduate Director, students may not be enrolled in any other degree program or certificate, at the University of Delaware or elsewhere while receiving department support.

3. Students receiving support through GA, RA, or TA must perform all required duties satisfactorily, as determined by their supervisor.

Satisfactory progress for the M.S. degree is defined as meeting all minimum registration and grade requirements. Those who wish to take the thesis option should have selected a thesis advisor and Thesis Committee before the start of the fourth semester of study.

Full-time students should meet the requirements for the M.S. after four semesters of study. Financial aid is not normally extended to terminal M.S. students past four semesters.

3.2 Degree Requirements for the Ph. D. in Mathematics and Applied Mathematics

An outline of the degree requirements for the Ph.D. is as follows.

1. Meet the coursework requirement (section 3.2.1).

2. Pass the Preliminary Examination requirement (section 3.2.2).

3. Pass the Candidacy Examination (see section 3.2.4).

4. Complete two semesters of experience in teaching undergraduate students, either as teaching assistant or as instructor of record.

5. Complete 9 credits of MATH 969 (Doctoral Dissertation) *in addition* to the coursework requirement in 1.

6. Complete and successfully defend a dissertation (section 3.2.5).

3.2.1. Coursework

There are two options for the coursework requirement: *standard* and *accelerated.*

Standard requirement

Students must complete 48 credits which can come from the following sources:

1. Any 600 level MATH course listed in section 3.2.3, up to a maximum of 27 credits
2. Any 800 level MATH course listed in section 3.2.3
3. MATH 868 ("Research") and MATH 870 ("Reading"), up to a maximum of 12 credits combined
4. Any 600 or 800 level non-MATH courses, up to a maximum of 6 credits. Exceptions may be granted by petitioning the Graduate Studies Committee.

These coursework requirements are a superset of those for the Master's degree which requires 30 credits. An M. S. degree is awarded once the requirements for it have been met, as discussed in Section 3.1.1.

Accelerated requirement

To qualify for the accelerated coursework requirement, the student must successfully complete the first tier of the Preliminary Requirement (section 3.2.2) before the start of the first semester (that is, by passing all required exams on the first possible date). Such an attempt at the exams counts as one of the student's regular allowed attempts. Additionally, the student must complete the second tier before the start of the third semester.

The accelerated course requirement is 30 credits, which can come from the following sources:

1. Any 600 level MATH course listed in section 3.2.3, up to a maximum of 9 credits except for MATH 600 and MATH 672. These two courses may not count towards the coursework requirement.
2. Any 800 level MATH course listed in section 3.2.3
3. MATH 868 ("Research") and MATH 870 ("Reading"), up to a maximum of 12 credits combined
4. Any 600 or 800 level non-MATH courses, up to a maximum of 3 credits. Exceptions may be granted by petitioning the Graduate Studies Committee.

Regardless of which track is taken, credit hours for which the grade is below C-minus do not count toward a

graduate degree.

3.2.2. Preliminary Examinations

All students who wish to obtain a PhD degree must complete the Preliminary Exam Requirement. The Preliminary Exam Requirement is divided into two tiers. The first tier consists of two exams and the second tier consists of a single exam. The first tier exams are Linear Algebra (with material related to MATH 672 and its prerequisites) and Analysis (with material related to MATH 600 and multivariable calculus). The second tier exam is to be chosen from the following list: Advanced Analysis (MATH 602), Numerical Methods (MATH 611), Applied Mathematics (MATH 617), Stochastic Processes (MATH 631), and Algebra (MATH 650). The courses help prepare students for preliminary exams, but the syllabi for exams and courses are not identical. It is *not* required that the course be taken before attempting the exam. Registration for specific exams opens 10 weeks before each session and closes 8 weeks before.

There will be three exam periods a year: one occurring at the end of the winter semester, the second a few weeks after the end of spring semester and the third immediately before the start of fall. In all three exam periods, any of the first and second tier exams will be offered, if requested by currently enrolled students or incoming students on the accelerated track. Each exam can be taken at most twice. In any one period, students can take at most two exams of the first tier and one exam of the second tier.

The first tier of the Preliminary Exam Requirement must be completed before the start of the third semester of study. The second tier of the Preliminary Exam Requirement must be completed before the start of the fourth semester of study.

Preliminary Exams are double blind: while the exams are associated with certain courses (see Section 3.2.3), they are normally written and graded by two faculty members who did not teach the course that year. Each faculty member grades the exam and rates the performance as *Acceptable* or *Unacceptable*. Results from each grader should be returned to the Graduate Committee within *10* days of the last exam date of the session.

When the two designations are *Acceptable*, the final designation will be *Acceptable*. When the two designations are *Unacceptable*, the final designation will be *Unacceptable*. When the designations conflict, the Graduate Director will mediate between the two graders to arrive at an ultimate designation. If the conflict is not resolved, the final designation will be *Unacceptable*.

Students will be notified of their final results within *4* days of the Graduate Committee approving the results from faculty graders. All results will be released at one time.

A student who fails the same individual exam twice (through two final Unacceptable designations) or fails to complete each tier of the Preliminary Requirement by the respective deadline will not be permitted to become a Ph. D. candidate and may lose financial support after the fourth semester. However, such students are still eligible for the M. S. degree.

For a student entering the program in the spring semester, the Director of Graduate Studies, in

consultation with the student, will determine the calendar for the Preliminary Requirement.

The syllabus to be covered by each examination, including suggested references, is kept by the department and available on the web and by request. Students may obtain copies of past examinations and the syllabus from the Graduate Studies Coordinator.

3.2.3. Courses offered by the Department

Below is a table of courses that are usually offered by the Department. Seven of these courses (MATH 600, 602, 611, 617, 631, 650, 672) are associated with Preliminary Exams.

Course Number	Course Name	Corresponding Preliminary Exam (if applicable)	Semester Offered
MATH 600	Fundamentals of Real Analysis	Analysis	Fall
MATH 602	Measure, integration, and Complex Variables	Advanced Analysis	Spring
MATH 611	Introduction to Numerical Discretization	Numerical Methods	Spring
MATH 612	Computational Methods for Equation Solving and Function Minimization	N/A	Fall and Spring
MATH 616	Modeling in Applied Mathematics	N/A	Fall
MATH 617	Techniques in Applied Mathematics	Applied Mathematics	Spring
MATH 620	Introduction to Mathematical Finance	N/A	Spring
MATH 630	Probability Theory Applications	N/A	Fall
MATH 631	Introduction to Stochastic Processes	Stochastic Processes	Spring
MATH 637	Mathematical Techniques in Data Science	N/A	Fall and Spring
MATH 650	Algebra I	Algebra	Spring
MATH 672	Vector Spaces	Linear Algebra	Fall
MATH 688	Combinatorics and Graph Theory I	N/A	Fall
MATH 806	Functional Analysis	N/A	Fall
MATH 810	Asymptotic and Perturbation Methods	N/A	Spring
MATH 817	Introduction to Numerical Methods for Partial Differential Equations	N/A	Fall
MATH 829	Topics in Mathematics	N/A	Spring
MATH 835	Evolutionary Partial Differential Equations	N/A	Fall
MATH 836	Elliptic Partial Differential Equations	N/A	Spring
MATH 838	Finite Element and Boundary Element Methods	N/A	Spring
MATH 845	Algebra II	N/A	Fall

MATH 850	Theory of Probability	N/A	Fall
MATH 888	Combinatorics II	N/A	Spring

3.2.4. Candidacy Examination

The purpose of the Candidacy Examination is to assess the student's readiness to undertake and complete a research project for the doctoral dissertation. Each student must pass the Candidacy Examination by the beginning of the student's sixth semester of study. For students using the accelerated coursework requirement, the Candidacy Exam should be completed before the start of the fourth semester. After passing the exam, students are encouraged to pursue Admission to Candidacy with the Graduate College. A student who fails the Candidacy Examination twice will be eligible for the M.S. degree but not the Ph.D.

Prior to taking the Candidacy Examination, the student must choose a Ph. D. advisor and research area. The Examination consists of two parts: (1) a public presentation (not to exceed 30 minutes) about the research area, including a summary of a relevant published paper, and (2) an oral examination (not to exceed two hours) by members of the student's Examining Committee.

The student should take the following steps to organize a Candidacy Examination and is advised to allow ample time for the process.

1. In consultation with the dissertation advisor, a committee of three faculty members, including the dissertation advisor, should be selected and contacted. In exceptional circumstances where specific expertise to be examined cannot be reasonably covered by a current member of faculty, the Graduate Committee can be petitioned to allow one external member of the committee.

2. Complete and submit the Candidacy Exam Proposal at least eight weeks before the requested examination date (or two weeks before a second attempt). The proposal must include:
   a) Date of the exam.
   b) A list of up to ten specific topics relevant to the student's research area, to be used as a guide to the oral examination. Typically, these will be topics chosen from the catalog descriptions or syllabi of the courses taken by the student.
   c) Full reference (author, title, publication data) of the research paper that will be presented by the student.
   d) Names and signatures of the dissertation advisor and all other members of the Examining Committee.

3. Receive approval or a request for revisions from the Graduate Studies Committee. Only after the Graduate Studies Committee has approved the proposal may the exam take place. The scheduling and composition of the Examination will be announced to the faculty.

Once the Examination has taken place, each member of the Examining Committee shall report the results, including a recommendation of Pass or Fail with written justification, to the Director of Graduate Studies within two business days.

A decision on the outcome of the Examination is the responsibility of the Graduate Studies Committee. Following a failed attempt at the exam, a student is permitted a second attempt. The same procedures should be followed. The research advisor, research area, Examining Committee, and published paper for presentation should all be identical to those for the first attempt; changes will be made only after petition to and at the discretion of the Graduate Studies Committee.

3.2.5. Dissertation

Students must select a dissertation advisor before completing the Candidacy Examination. The dissertation advisor will guide the preparation for the examination, including selection of the examining committee. Students should notify the Graduate Studies Coordinator when they have selected a dissertation advisor, or to change their selection at any time prior to filing the Recommendation to Candidacy form.

The dissertation is expected to reflect the results of original, significant research written in a literate and scholarly manner worthy of publication. The student must defend his or her dissertation before a Dissertation Committee consisting of the student's dissertation adviser and no less than three and no more than five additional members. At least one and at most two members must be from a different academic unit. This committee must be designated, with members' signatures, on the Recommendation to Candidacy form. The form must be filed again if the student wishes to change the Dissertation Committee.

The student is responsible for following the Graduate College deadlines and procedures relating to the dissertation, defense, and application for the degree. The final draft dissertation will be supplied to the committee members a minimum of four weeks before the date of the oral defense. The time, date, and place of the oral defense will be announced to the faculty, and the defense will be open to the academic community.

3.2.6. Timetable and satisfactory progress

All students are subject to the regulations of the Graduate College. The Graduate College sets specific policies regarding probationary status and satisfactory progress. In particular, a student must maintain a cumulative GPA of 3.0 or better or risk dismissal. A student must have a cumulative GPA of 3.0 or better in order to receive a graduate degree.

The Graduate College requires *six* credits of graded coursework per semester to be registered as a full-time student funded on a Teaching Assistantship (TA), Research Assistantship (RA) or Graduate Assistantship (GA). This applies to all students, whether domestic or international. However, many students in the Department of Mathematical Sciences take nine credits in addition to their TA, RA or GA duties and/or training. *Nine* graduate credits or sustaining in the fall and spring semesters is the minimum registration requirement to be classified as a full-time for students who are self-funded or receive a fellowship.

In addition to Graduate College regulations, the following regulations are specific to the Department of Mathematical Sciences for students receiving financial support through GA, RA, TA, or departmental/university fellowships. Except where noted otherwise, students seeking a waiver of any these regulations must petition the Graduate Studies Committee

1. No more than nine credits of graded coursework may be taken without the permission of the Graduate Director. Students are permitted to register as "listener" for up to three credits beyond the nine graded credits.

2. Unless approved by the Graduate Director, students may not be enrolled in any other degree program, at the University of Delaware or elsewhere while receiving department support.

3. Students receiving support through GA, RA, or TA must perform all required duties satisfactorily, as determined by their supervisor.

Satisfactory progress for the Ph. D. degree is defined as meeting all minimum registration and grade requirements.

In addition to the regulations above, a timeline for satisfactory progress toward the Ph.D. is as follows.

Standard coursework option:

1. Pass the first tier of the Preliminary Requirement before the beginning of the third semester of study.
2. Pass the second tier of the Preliminary Requirement and file a Change of Classification form before the beginning of the fourth semester of study.
3. Select a dissertation advisor and Dissertation Committee, file a plan for the Candidacy Examination, and successfully complete the Candidacy Examination before the start of the sixth semester of study.
4. Submit the Recommendation to Candidacy form in order to complete 9 credits of MATH 969 ("Doctoral Dissertation").
5. Upon approved registration of MATH 969, students are released from minimum course enrollment requirements. Instead, they will be enrolled in Doctoral Sustaining (UNIV 999). A student must be registered in the semester in which the degree is awarded.

Accelerated coursework option:

1. Pass the first tier of the Preliminary Requirement before the start of the first semester of study.
2. Pass the second tier of the Preliminary Requirement before the start of the third semester of study.
3. Select a dissertation advisor and Dissertation Committee, file a plan for the Candidacy Examination, and successfully complete the Candidacy Examination before the start of the fourth semester of study.
4. Submit the Recommendation to Candidacy form in order to complete 9 credits of MATH 969 ("Doctoral Dissertation").
5. Upon completion of MATH 969, students are released from minimum course enrollment requirements. Instead, they will be enrolled in Doctoral Sustaining (UNIV 999). A student must be registered in the semester in which the degree is awarded.

After each semester, all students are reviewed by the Director of Graduate Studies as to whether satisfactory progress toward the degree is being met. If a student who, in the determination by the Directory of Graduate Studies, has not met satisfactory progress, the student will be given detailed written notice that has led to the Director's decision along with the recommendation for suspension of financial support or a recommendation for dismissal from the program. The student may appeal the Director's decision to the full Graduate Studies Committee. The student must submit in writing the response to the issues of failure that the Graduate Director has provided within 10 business days. If the Graduate Studies Committee supports the decision of the Graduate Director, the student can then appeal to the Chair of the Department. If the Chair supports the decision of the Graduate Director, the Graduate Director will send a report to the Associate Dean of the Graduate College that states the decision causing dismissal and the

justification for this action. The Associate Dean of the Graduate College will notify a student in writing when the student is being dismissed for failure to make satisfactory progress in the program.

In the case of academic dismissal, the student may appeal the termination by writing to the Dean of the Graduate College. This appeal must be made within ten class days from the date on which the student has been notified of academic dismissal. The Dean will review the appeal and may either uphold the dismissal, grant reinstatement or refer the case to the Graduate Hearing Board for resolution. If the Dean grants reinstatement, the student must meet the conditions of the reinstatement. Failure to meet these conditions will result in dismissal from the program. A graduate student may be reinstated only once to a given major. The student's academic transcript will reflect the reinstatement with the appropriate academic probation status.

4. Assessment

All graduate programs in the Department of Mathematical Sciences are designed to take high-quality students, with a strong background in mathematics, and transform them into full-fledged practitioners of the discipline of mathematics. For students seeking the M.S. the Department seeks to broaden and deepen their knowledge of mathematics and properly train them for a mathematics related career. For students seeking the Ph.D. the Department again seeks to broaden and deepen their knowledge of mathematics and to train them as practitioners so that they may impact the discipline in a deep and meaningful way.

1.1. Learning objectives

The Department's programs in Math and Applied Math focus on several key educational goals.

Educational Goals for M. S. degrees

Students who graduate from the *Mathematics M. S.* program will be prepared for quantitative careers in industry or academia. Students who successfully complete this program will be able to:

- Recall and apply concepts from core subject areas including Vector Spaces, Analysis, and other topics such as Numerical Methods, Complex Variables and Integration, Probability, and Algebra
- Use technology to gain insight into mathematical structures
- Communicate mathematical ideas at a level appropriate for the audience

Students who graduate from the *Applied Mathematics M. S.* program will be prepared for quantitative careers in industry or academia. Students who successfully complete this program will be able to:

- Recall and apply concepts from core subject areas including Vector Spaces, Analysis, and other topics such as Numerical Methods, Complex Variables and Integration, Probability, and Applied Mathematics
- Use technology to gain insight into problems from engineering, natural science, computer science, operations research, or other application domains
- Communicate mathematical ideas at a level appropriate for the audience

Educational Goals for Ph. D. degrees

Students who graduate from the *Mathematics Ph. D.* program will be prepared for a career of research, either in industry or academia. Students who successfully complete this program will be able to:

- Recall and apply concepts from core subject areas including Vector Spaces, Analysis, and other topics such as Numerical Methods, Complex Variables and Integration, Probability, and Algebra
- Integrate and synthesize knowledge gained from core courses to develop a research program
- Use technology to gain insight into mathematical structures
- Explain how their research extends knowledge and understanding in their field of specialization
- Present mathematical ideas at a level appropriate for the audience
- Write mathematics at a level appropriate for publication or dissemination
- Navigate the steps of the scientific publishing process, understand disciplinary standards of citation, and award credit to other scholars when appropriate.

Students who graduate from the *Applied Mathematics Ph. D.* program will be prepared for a career of research, either in industry or academia. Students who successfully complete this program will be able to:

- Recall and apply concepts from core subject areas including Vector Spaces, Analysis, and other topics such as Numerical Methods, Complex Variables and Integration, Probability, and Applied Mathematics
- Integrate and synthesize knowledge gained from core courses to develop a research program
- Use technology to gain insight into problems from engineering, natural science, computer science, operations research, or other application domains
- Explain how their research relates to a specific application area and how it generally fits into the larger body of science
- Present mathematical ideas at a level appropriate for the audience
- Write mathematics at a level appropriate for publication or dissemination
- Navigate the steps of the scientific publishing process, understand disciplinary standards of citation, and award credit to other scholars when appropriate.

1.2. Assessment Plan

In order to ensure that the graduate programs are meeting the objectives stated above, learning outcomes are continually monitored. For each of the educational goals, the Department relies upon a variety of assessment tools:

Educational Goal	Assessment Tool/Method
Recall and apply concepts from core subject areas	Preliminary Exams and courses
Integrate and synthesize knowledge gained from core courses to develop a research program	Oral candidacy examinations, written theses, and oral theses defenses.
Use technology to gain insight into mathematical structures/problems from engineering, natural science, computer science, operations research, or other application domains	Courses with a computational component and student theses
Explain how their research extends knowledge and understanding in their field of specialization/relates to a specific application	Written theses, oral theses defenses, seminar and conference presentations

area and how it generally fits into the larger body of science	
Present/communicate mathematical ideas at a level appropriate for the audience	Oral theses defenses, seminar and conference presentations, courses
Write mathematics at a level appropriate for publication or dissemination	Published papers and conference proceedings
Navigate the steps of the scientific publishing process, understand disciplinary standards of citation, and award credit to other scholars when appropriate.	Published papers and conference proceedings

5. Financial Aid

Financial aid for study in the department takes several forms, including Research Assistantships, Departmental and University Fellowships, Teaching Assistantships, Graduate Assistantships, and Tuition Scholarships. These forms of financial aid are awarded by the department on a yearly basis. Continuation of financial support is not automatic; it is dependent upon maintaining satisfactory progress, as defined in Section 3.2.6. All students receiving support of any kind are required to perform any assigned supplemental tasks, such as proctoring of examinations. Failure to carry out assigned tasks in a prompt and competent way risks termination of financial support.

All students on departmental or university funding (that is, exclusive of Research Assistantships, external fellowships, and non-departmental Teaching Assistantships) receive the same stipend for fall and spring semesters, at an amount set by the Director of Graduate Studies not less than the university's minimum.

The Department encourages students to compete for nationally advertised graduate fellowships. Information on what fellowships are currently available can be obtained from the Graduate Studies Coordinator. It is expected that all graduate TAs prepare themselves for classroom teaching. All new TAs are required to participate in university and department TA training programs.

5.1. Support for student travel

The department encourages graduate students to attend national meetings and workshops and supports this by providing funding for student travel. Students should note that additional funds are often available from the Graduate College, their dissertation advisers, and other travel fellowship opportunities.

Students who have met the Preliminary Examination requirement (Section 3.2.2.) and who receive financial aid are eligible for $500 of travel support. Those who have moved into sustaining student status are eligible for an additional $500. It is not necessary to use the first travel award amount before becoming eligible for the additional amount.

Guidelines for use of these funds are as follows:

1. The student must have completed the relevant examination requirement(s) before applying for the use of travel funds.
2. The student must be registered as a full-time student in good standing in the department's graduate program for at least the two consecutive semesters before the time period in which travel is to occur.
3. The student's stipend must be paid by departmental or university sources at the time of application for the use of travel funds.
4. Travel must be fully completed before the completion of the terminal degree to be granted by the department.
6. The student must use the travel money to pay the costs associated with attending scientific meetings or other educational or academic events.
7. The student must fill out a travel approval form obtained from the Graduate Studies Coordinator. The form must be completed and approved before travel commences. In no case will students be reimbursed for travel without prior approval of this form.

8. The Director of Graduate Studies makes the decision to approve every travel request.

The Graduate College offers matching travel funds; students are advised to apply for these funds. Students may be eligible to receive additional funds from the department to visit their undergraduate school (in North America) to help recruit new graduate students, or for extraordinary additional opportunities. Requests for these funds should be made to the Director of Graduate Studies.

5.2. Summer support

Graduate student contracts for teaching assistantships and fellowships are for fall and spring semesters. (Research assistantships and external fellowships may be negotiated differently.) There are typically opportunities for summer teaching and research contracts. In addition, the department offers summer support as follows:

1. Continuing students with financial support who have completed the first two semesters of full-time study in the department's graduate program are eligible for summer support according to conditions specified in their offer letter. These funds are not available to 4+1 B.S./M.S. students. Students are expected to be in residence during a ten-week period (typically, the first summer session) and meet any other expectations set by the Graduate Studies Committee.

2. Students receiving either type of stipend must comply with regulations from the Graduate College: see https://www.udel.edu/academics/colleges/grad/current-students/academic-support/policies/ for details.

6. Teaching for the department

For foreign students, preparation for classroom duties includes mandatory participation in the English Language Institute (ELI) training in the month before the fall or spring term, as appropriate. ELI must certify that a foreign student has a sufficient command of English and teaching basics (Category II based on SPEAK and UDIA scores) before the Department can make a classroom assignment. It is departmental policy that no foreign student be supported for more than two semesters without being certified for classroom assignments by ELI.

Two semesters of in-classroom teaching, including both teaching assistant (TA) and instructor assignments, are a requirement for the Ph.D. The Department teaches a substantial fraction of all undergraduate students on campus each year and expects a high level of performance from all who contribute. Students should keep in mind that satisfactory progress towards their degree includes acceptable performance of all required duties. **Failure to carry out assigned tasks in a prompt and competent way risks termination of financial support.**

All teaching is assigned and overseen by the Associate Chair of the department, who maintains a detailed description of duties and expectations for TAs. Students should contact the Associate Chair if they have not received a copy of those guidelines. Course instructors and coordinators also play important roles in TA oversight.

Some courses, including many of those that use TAs, are taught in a lecture/discussion format. The TA

duties in such a course often include running one or more discussion sessions each week for relatively small numbers of students. Other TA duties might include grading homework, holding office hours, proctoring and grading exams, answering email questions, and more. **It is the TA's responsibility to determine and follow the instructor's specific expectations for each section assigned**.

Students should plan to be on campus during the entire semester for their teaching assignment, except for official breaks in the academic calendar. Absences during the semester must have authorization from the Associate Chair in advance. **Students should never schedule a long departure from Newark before the last day of the final exam period.** They must attend all the classroom meetings and office hours that they are required to conduct. They should notify the department staff as soon as possible if they must miss a section meeting or office hours due to illness or emergency.

Student contracts state that they may be required to perform up to 20 hours of work per week as a TA. In addition to the activities listed above, they must budget time for preparation and for thoughtful development of their teaching. They may also be required to proctor exams in other courses by the Associate Chair. Students consistently devoting more than 20 hours per week to their TA duties should first speak to their supervising instructor(s) or course coordinators, and then speak with the Associate Chair if the situation still cannot be resolved.

Students who perform TA duties well may get opportunities to teach as instructor of record during Winter or Summer sessions. These assignments are made by the Associate Chair. If they are assigned as the instructor for a section that has fewer than ten students after the first meeting, they should notify the Associate Chair immediately.

In addition to offering extra income, instructor assignments should be seen as critical professional development opportunities. Students often need to show a proven track record of development in their teaching to obtain an academic job and should consider requesting a classroom observation from faculty or the campus' teaching effectiveness center.

7. Miscellaneous information

Contact information. Student phone numbers and local addresses, and emergency contact phone numbers should be on file with the university or Graduate Studies Coordinator. This information should be kept up to date at all times.

Class supplies. TA classroom supplies (as opposed to personal supplies) may be secured from the workroom supply cabinet. These supplies are for the classes that students are *teaching*, not the classes they are *taking*.

Computer accounts. Students are automatically given a university email account (udel.edu address). For instructions on activating the account, they should refer to www.udel.edu/help. Students should use their computer account responsibly and for work-related tasks only, or their account may be limited or revoked.

Typing of tests. Department staff do *not* type or typeset exams or any other materials for students.

Keys. The keys issued to students are for offices in Ewing Hall and outside entrances to Ewing Hall. The office key opens Ewing public areas: work rooms, computer terminal rooms, and the conference rooms.

Pay. Students are paid twice monthly, on the 15th and the last day of the month. In order to receive their first check, they will need to fill out a W-4 form and an I-9 form for tax purposes. Foreign students who receive temporary Social Security Numbers will need to fill out a second W-4 form when they receive their permanent Social Security Numbers. These students must also change their UD ID cards. All graduate students must use direct deposit, which requires filing a form that they can obtain from staff. Student pay stubs can be viewed online. Their stipend is automatically paid continuously through all nine months of the academic year, including the period between fall and spring semesters. If they are paid through an additional winter session contract, the amount will be added to their other stipend over the winter session period. Summer session payment is handled through separate contracts for additional work duties. Students should notify the Associate Chair if they are interested in teaching in winter or summer sessions.

Textbooks. Desk copies may be obtained in the main office for courses in which students are a teaching assistant or instructor. These books must be returned to the department immediately after the course is over.

Copying. Photocopying is available at no charge *only* for work in any course in which students are a teaching assistant or instructor. Students must reimburse the department for the cost of any photocopying for personal use. The photocopy machines should not be used for large copy jobs. Students should see the office staff for any copy job exceeding 150 pages in total.