Department of Mathematics
Graduate Student Handbook

2018-2019

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Introduction

The graduate program in Mathematics is aimed at guiding students toward original research. At the end of the program (normally by the end of the fifth year of study) students are expected to submit and defend a PhD thesis that contributes new results to the body of mathematical knowledge.

To successfully deal with problems arising in modern mathematics, graduate students need to acquire a considerable background. This is achieved through course work and independent study. The program provides for two sets of examinations to verify the progress:

- Preliminary Examination (normally passed by the end of the first year)
- Qualifying Examination (often passed by the end of the second year)

Advisers

Each graduate student has an adviser to help design his/her program and to closely guide his/her mathematical development. The Chair of the Graduate Committee may also be consulted about any aspects of the requirements, planning the program of study, or any other matter pertaining to the graduate studies.

A student in his/her first and second year is assigned an adviser from the Graduate Committee in September of each academic year before he/she chooses a dissertation advisor. A student preparing for the qualifying examination is advised by the chair of his/her committee. A student writing a dissertation is advised by the dissertation supervisor.

It is vitally important that the students begin thinking about a possible dissertation supervisor sufficiently early in the program (normally toward the end of the first year, or the beginning of the second). Students should be constantly browsing different areas of mathematics and discussing math informally with classmates and faculty, as they search for the fields which attract them most.

Students are advised to learn more about the research of the faculty members as early as possible, starting with the current listings of faculty and their research interests. Graduate students may organize seminars in which they invite faculty to explain their

areas of research. Students are expected to attend department colloquiums, and may benefit from some of the many research seminars.

Graduate students with learning disabilities are encouraged to contact the Director of Graduate Studies and the Office of Services for Students with Disabilities (ssd@northwestern.edu).

Course Registration

Graduate courses are an essential component of a mathematician's training. Graduates of the Northwestern mathematics program are expected to be well-rounded, in part by having taken courses in a wide variety of subjects. In addition, several courses are research-oriented and presentation-based, offering training for some of the specific skills needed by research mathematicians. Beyond these general expectations, the departmental and University legislation provides for certain minimal requirements related to the course work.

The minimal full-time course load for Mathematics graduate students in the first three years is three (3) courses per quarter. It is possible to register for four (4) courses with no increase in tuition. Graduate students in each of their first three years are required to enroll in at least seven (7) regular mathematics courses (i.e., **not** including 499 independent study courses) each year, and at least one (1) such course per quarter. Students who have passed their qualifying examination may count post-candidacy research (TGS 500) toward this requirement. Substitutions or exceptions require the advanced approval of the Graduate Committee.

Graduate students must fulfill a residency requirement of nine (9) quarters (=3 years) of full-time registration in ordinary courses. After fulfilling this residency requirement and passing the Qualifying Examination, a student should register for TGS 500 (Advanced Doctoral Study). This reduces the tuition and maintains full-time status. If a graduate student has passed the qualifying exam but not yet fulfilled the residency requirement, the student may register for Math 590 in lieu of TGS 500.

Summers: By the end of each academic year, each student is required to submit a list of the courses taken, in order to demonstrate compliance with the course work and registration requirements outlined herein. Each student receiving a university fellowship for the upcoming summer must submit, prior to the end of Spring Quarter, to the Graduate Program Assistant a program of study for the summer months, approved by a supervising faculty member.

Independent Study

Independent study courses ("499"; also called "reading courses") are an excellent way for students to explore specific topics not covered by the regular course offerings. They

are also a way for students to learn of areas of research of the faculty. As such, they play an essential role for graduate students in search of an adviser.

A student wishing to enroll in 499 must file a brief syllabus, prepared by the faculty member supervising the Independent Study, with the Graduate Program Assistant by the first day of class, using this form. Independent study courses should not duplicate regular courses offered by the department. In particular, if a course was offered in the near past or will be offered in the near future, then a request to enroll in a 499 course in a similar subject would most likely be denied.

Preliminary Examination

All students must pass the Preliminary Examination in order to continue with the program.

The Preliminary Examination consists of written examinations in the following three subjects: algebra, analysis, and geometry/topology.

Incoming students are invited and encouraged to take the Preliminary Examination upon entrance. There is no penalty for failing to pass a preliminary examination taken upon entrance to the program.

Incoming students will be required to take the first-year course in each of the prelim subjects they do not pass upon entrance, unless they submit documentation of having passed a comparable course at another institution (or other compelling evidence of familiarity with a subject).

Syllabi for the preliminary examinations and copies of past examinations are available online at the department website.

The rules for the Preliminary Examination are posted here.

The Preliminary Examination is given during New Student Week in September and at the end of the academic year (typically during Weinberg College's final exam week in June). Graduate students must take the Preliminary Examination in all three subjects by the end of their first academic year. Students who do not pass the Preliminary Examination by the end of their first year must pass a make-up examination in September at the beginning of their second year in order to continue in the program beyond the first quarter of the second year. In the presence of strong evidence of other mathematical accomplishment, this rule may be modified or waived with the approval of the Graduate Committee.

An award is offered at the end of each academic year to the student who has achieved the excellent performance in the Preliminary Examination. The award is accompanied by a monetary prize.

Master's Degree

Passing the Preliminary Examination and completing at least nine approved courses over at least three quarters of registration will satisfy the departmental requirements for a master's degree. The deadline for filing the form with the Graduate School in order to receive the degree at the June degree ceremony is the beginning of Spring Quarter. Students intending to apply for a master's degree should approach the Graduate Program Assistant at least 3 weeks prior to this deadline.

Qualifying Exam

A student becomes a Ph.D. candidate after successfully completing six quarters of course work and the Qualifying Examination. This is the last examination before a student begins dissertation research. This examination serves at least two purposes:

- To acquaint faculty members with the research potential and interests of the student, and the student with the research interests of faculty members.
- To determine whether the student can read and assimilate advanced material in a specialized field.

The Qualifying Examination is an oral examination. After the student has decided upon a field of interest, he/she asks a faculty member to chair a committee to conduct his/her Qualifying Examination. The chair, in consultation with the student, selects at least two other faculty members to comprise the committee. The committee members, in consultation with each other and the student, assign topics and a reading list to the student. The committee must be comprised of at least three faculty members, at least two of whom are NU graduate faculty.

Students preparing for the Qualifying Examination must submit for approval the qualifying examination form to the Graduate Program Assistant at least three weeks prior to the exam date.

The Qualifying Examination must be taken by the end of the first quarter of a student's third year. Failure to pass the exam by the end of the third year may jeopardize financial support in the subsequent year.

Prospectus

Students must have a prospectus (dissertation proposal) approved no later than the end of the fourth year of study, which falls on the last date of the 16th quarter. A student failing to meet this milestone will be considered not in good academic standing and therefore will be placed on academic probation. Deadlines will be altered in the case of an approved leave of absence or a childbirth accommodation. The prospectus must be approved by a faculty committee comprised of a minimum of three individuals. At least

two members of this committee, including the chair, must be members of the Northwestern University Graduate Faculty. Students may choose to have their prospectus approved by the faculty committee members via electronic communication or an in-person meeting. The student must then submit the PhD Prospectus form through TGS Forms in CAESAR for program approval. <u>The student's adviser must email the Graduate Program Assistant to confirm the student's successful completion of the prospectus.</u> Students are notified via email by TGS of approval of their Prospectus form.

Waivers

In order to maintain flexibility in the graduate program, and, in particular, to accommodate exceptional cases, the Graduate Committee will consider written requests from students' advisers to waive or modify requirements. However, it is expected that such requests will be granted only rarely.

Financial Aid

There are several types of financial aid awarded by the department and the University on the basis of merit. According to regulations of the United States IRS, all awards are taxable.

Financial aid is typically offered to graduate students for five academic years. The Graduate Committee decides whether to renew a student's support based upon his/her progress from year to year. For a first year student, progress will be determined from course grades and reports solicited by the Graduate Committee; for this purpose, a GPA of 3.0 or lower is not considered adequate preparation for further study. Students are expected to pass the Preliminary Examination by September of the second year and the Qualifying Examination by the end of the first quarter of the third year.

Financial aid from Northwestern consists of a mixture of fellowships and graduate (teaching) assistantships. A student with a non-English speaking background may be required to demonstrate fluency in spoken English before he or she can hold a graduate assistantship. Failure to do so may result in academic probation, loss of funding, and even exclusion from the program. See [Graduate Assistantship](#) for the precise requirements.

It is a policy of the Graduate School that teaching assistants and University Fellows may not undertake other employment without the prior permission of The Graduate School. This includes any stipend or fellowship at another institution.

<u>Residency during Fellowship Quarters</u>

The department is required to certify that all graduate students on any fellowship are working full-time on mathematics research; therefore, we normally expect fellowship students to be in residence. Exceptions are possible for extraordinary research

opportunities. Such exceptions require explicit permission of the student's adviser and the departmental graduate committee.

Outside Funding

We encourage students to apply for funding from outside sources during their study at Northwestern. Such outside funding will be banked for the student and can be used as fellowship quarters for a possible 6th year. Funding through the student's advisor's and the department's grants is not considered as outside funding for this purpose. If any banked quarter accrues to the student as a result of such funding, it will be banked as a fellowship or teaching assistantship quarter, depending on the duties the funding replaced. According to TGS regulations, a student can bank at most four quarters from all funding sources not coming from TGS.

Teaching Policy

Teaching experience is considered to be an integral part of the training of all graduate students, and is required each year of all students, with the exception of students in their fifth year of study. First-year students usually fulfill this requirement by assisting with grading. Upper-level students fulfill this requirement by serving as a teaching assistant for at least one course in an academic year.

Potential employers, particularly academic employers, often specifically inquire about the quality of teaching performed by job candidates from the department. Our students have found teaching experience to be a valuable asset.

Teaching Activities

Undergraduate teaching is one of the primary responsibilities of the Mathematics Department; graduate students play an important role in this function. As a part of their training, and as a necessary condition for most forms of financial aid, all teaching assistants are involved with departmental teaching activities each quarter they are in residence. Most often they assist faculty members by conducting the recitation sections of calculus and other undergraduate courses; they may on occasion be asked to grade for graduate courses.

Course Assignment Responsibilities

Responsibilities to each course assignment begin on the first day of classes of that quarter and end 48 hours after the final examination.

The work of teaching assistants varies with the course and the faculty member who has primary responsibility but generally includes answering questions about homework problems in the recitation section (which meets weekly for each course), grading homework, and proctoring and grading quizzes, mid-terms, and final exams. The faculty

member teaching the course makes specific arrangements with his/her teaching assistants concerning their duties. Recitation sections meet on Tuesday or Thursday; the lectures are on Monday, Wednesday and Friday, although there may be occasional departures from this model. Classes begin on the hour and last for 50 minutes.

It is department policy that a teaching assistant's assigned instructional duties should take no more than four hours per course per week. A teaching assistant who feels he/she is overburdened should consult with the professor in charge of the course. If problems persist, the Director of Graduate Studies should be notified.

Teaching assistants should have at least three formal, announced office hours each week during which students may meet with them. These office hours serve for all of the classes for which the graduate student is a TA. Teaching assistants should choose times when students are likely to be able to come (so 9am is bad, as are the popular lecture hours like MWF 11), so as to avoid multiple requests for appointments at other times. Holding some office hours in the early evening is another possibility. One good strategy is to have office hours straddle two class time-slots, for example 1:30-2:30 pm; this will make them available to more students. Finally, TA's for courses with graded homework should schedule office hours for the day before the homework is due, not the day after. Check with your professor to see what his/her preference is, as well.

The department and the graduate school organize several different training sessions for its new teaching assistants; all new teaching assistants are expected to attend. For second year graduate students, there is a required teaching seminar during the fall quarter (see Training section below).

Faculty members are required by College legislation to have their undergraduate courses evaluated by the students; this includes an opportunity for students to evaluate their recitation sections. The information collected is returned to the faculty member and to the department chairperson. This, and other methods of evaluation, are used by the department in assessing how well teaching assistants are carrying out their duties. A graduate student whose teaching is determined to be unsatisfactory may become ineligible for University financial support.

Every year we will have a few openings for graduate students to teach a class in one of our calculus sequences, where they will receive supervision and mentoring from an experienced faculty member. To be eligible for this opportunity, the student must

> (a) have demonstrated excellence as a TA, as evidenced by CTECs and in-class evaluations, and

> (b) have evidence of initiative and interest in teaching, and

> (c) have the permission of their advisor.

Examples for part (b) might be teaching in SPS in the summer or evening, or working with the Searle Center in one of their programs for graduate students. Other options are possible.

Training

Graduate students undergo teacher training during the fall quarter of their second year by participating in Math 580: Seminar in College Teaching. First-year students perform supervised grading of exams in one undergraduate course per quarter.

Summer School Teaching

In order to provide teaching experience and some summer support, some students are given the opportunity to teach in the Summer School. This is usually offered to advanced students, chosen on the basis of evaluations of performance as a teaching assistant.

Minimum In-class Teaching Experience

In-class teaching is an essential responsibility of a mathematician in a research and/or teaching career. A graduate student must have served as teaching assistant (or, in exceptional cases, lecturer) in a role that involves meeting with a class (typically, running a discussion section -- grading does not count) in at least three quarter-long courses at Northwestern or other institutions before completing a PhD.

Language Proficiency

Teaching is an essential element of the education and training of PhD students. For this reason TGS and the Mathematics Department require that all students serve as Teaching Assistants during their career at Northwestern. In order to be able to teach, students must be certified as proficient in the English language. If the student is from an English-speaking country or has attended an undergraduate institution where the instruction is in English, this is automatic. Otherwise, TGS offers four ways to demonstrate proficiency detailed at the following site:

http://www.tgs.northwestern.edu/funding/assistantships/graduate-and-teaching.html

We hope that all students meet the proficiency requirement by the end of the first year. Northwestern has many resources and classes for learning English. These can be found here:

http://groups.linguistics.northwestern.edu/esl/

It is up to the student to avail themselves of these resources.

Students who have not met the English proficiency requirement by end of the first year will use fellowship quarters for their support beginning in the Fall quarter of the second year. Any fellowship quarter used in the second year will be deducted from the student's total of six allotted fellowship quarters.

Students who do not meet the requirement by the end of the second year will be deemed to be not making satisfactory progress as defined in this Handbook and will be placed on probation. As with any probation, the student will be informed in writing the steps needed to meet the requirement and any deadline that must be met. Failure to complete these steps could lead to exclusion from the program.

Travel/Book Fund

Each graduate student has access to limited yearly funds available to use for travel or book purchases related to graduate studies. First year graduate students receive $1,000 total per year (<u>$500 cap on book purchases</u>). All other graduate students receive $750 total year (<u>$250 cap on book purchases</u>). The travel/book fund is available to use from September 1 – August 31 each year. Funds may not be carried over to the next academic year; any unused funds will be forfeited at the end of the year.

<u>**Travel**</u>

The Mathematics Department has limited funds allocated to support graduate student travel to present work or attend conferences and seminars of relevance to a student's educational and/or professional development.

The student should first approach his or her adviser to inquire about funding through a grant held by the adviser. Please note that funding from federal grants will carry additional limitations beyond the standard University policy, such as requiring US air carriers for foreign travel, and no alcohol. More information can be found at the following link:

http://www.northwestern.edu/financial-operations/policies-procedures/policies/travel.pdf

The student should also seek funding from other sources, such as a hosting institution or conference organizers.

After these steps are taken, the student may apply for travel support from the Mathematics Department directly. The student should submit the application(s) as early as possible to secure funding before booking travel, but certainly at least one month prior to the date of travel. The student will receive a written response within 10 days.

To apply, the student should submit by e-mail to the Graduate Program Assistant (Emily Green) a description of the conference (including titles, dates, web URL's) and the intended use and total amount of funding requested. The application should also specify other sources and amounts of funding that the student has applied for/secured.

After the travel is complete, the student should create an expense report and submit original receipts to the department office. The student also should submit by e-mail to the Graduate Program Assistant a summary paragraph describing how the completed travel benefits the student's educational and/or professional development.

Once the summary paragraph has been received and approved, funds will be released for reimbursement.

NOTE: A student seeking travel support for a conference or seminar at which he or she has an opportunity to contribute a presentation must concurrently apply for a Graduate School Travel Grant. Applications are available at The Graduate School website. The student may consult with the Business Administrator (Greg Jue) regarding budgetary questions on the application as necessary.

Book Fund

A graduate student may utilize the travel/book fund to make a book purchase through the office at any time during the year. To make a purchase, the student should email the Graduate Program Assistant the website link to purchase the book. Amazon is the most commonly used vendor, though other vendors can be used. The Graduate Program Assistant will then complete the purchase and inform the student when the book is ready to be picked up from the Math Office (Lunt 201).

Awards

Four awards are given annually to graduate students.

- An award for the excellent performance on the Preliminary Examination is given at the end of the year.
- The Gelfand Award is given at the end of the year to that student who has contributed most to the department.
- The Best Thesis Award is given each year to a graduating student.
- The Graduate Teaching Assistant Award is given each year to a TA.

Events

Teas

One of the best ways to get to know faculty and other graduate students is to attend the departmental teas. These are held in the Common Room, Lunt 218, every afternoon on weekdays at 3:45pm.

Seminars and Colloquia

Students are strongly encouraged to participate actively in departmental seminars and are expected to attend department colloquiums. The colloquiums, in particular, are meant for a general mathematical audience with no specialized knowledge. A complete list of seminars and colloquiums is available on the [Mathematical Calendar webpage](#).

Facilities

Library

The R. P. Boas Mathematics Library is located on the first floor of Lunt Hall; it has a large collection of books and journals. Some books may be placed on reserve for beginning graduate courses so all the students can have access in the library. Journals must be used in the library, though they may be signed out briefly for copying. The librarian can explain the details of book circulation policies. Normal library hours are weekdays from 8:30 a.m. to 5:00 p.m. Graduate students have after hours access to this library via Wildcard.

Other books and journals of interest, especially those in applied mathematics, can be found in the Science-Engineering Library, east of the Technological Institute.

Computing Facilities

Many members of the Math Department at Northwestern University use computers in important ways in their research. The department has its own subnetwork with about 50 computers in offices occupied by faculty members and staff. There is also a public computer lab in Lunt B10 with computers used as terminals to access accounts on the Math servers. These computers and three laser printers are housed in Lunt Hall and are used exclusively by the faculty and graduate students in the Math Department. Computers in the Math Department support Mathematica for symbolic and numeric mathematical calculations as well as graphical display of their output, TexT/LaTeX and related typesetting packages, and other packages that can be install on demand – consult the computer system administrator Miguel A. Lerma for additional information.

Graduate students can obtain accounts on the department's internal computer network, and are encouraged to become familiar with its use. Each entering student should see Miguel A. Lerma to set up an account. The department discourages excessive personal use of departmental computer resources.

The university provides many additional computer services through Information Technology. One of the most useful of these is the campus WiFi network, accessible using your NetID.

Where to Find It

Mailboxes: Mailboxes for faculty and graduate students are located outside Room 201.

Photocopy machine: Room 202. Obtain a user number from the department office to use the machine.

Office supplies: Paper, pencils, pens, stationery, etc. are available in reasonable quantities from the office staff in Room 201.

Texts for TA's: Desk copies of textbooks are available from the Departmental Office.

Computers: Several Linux computers and one Microsoft Windows XP are in Room B10. There is one laser printer in the hall of the basement and one laser printer in Room 202.

Satisfactory Academic Progress

To remain eligible for all forms of financial aid, students must meet the [criteria for satisfactory academic progress](#) set by The Graduate School. In addition, students must fulfill the Preliminary Exam requirement set by the department.

For students who are unable to make satisfactory academic progress, the department follows the TGS policies for [academic probation](#) and [dismissal](#). Students wishing to appeal a dismissal decision should follow the [appeal process guidelines](#) set forth by TGS.

Objectives, Goals, and Assessment

Graduate Program: PhD in Mathematics

Mission Statement: The graduate program is aimed at guiding students toward original research. At the end of the program (normally by the end of the fifth year of study) students are expected to submit and defend a PhD thesis that contributes new results to the body of mathematical knowledge.

Learning objectives	Milestone/ Requirement/Capacity	Assessment Strategies and Criteria*
Design and implement a research project.	Dissertation/ Research	Faculty committee reviews projects with specific criteria, demonstrating levels of achievement. Offers an original thesis; defines appropriate methodology; delineates sources; adheres to scientific method.
Write a research paper	Research	Posts to the arXiv; submission to peer reviewed journals. Successful written communication of original research
Articulate broader impacts of research	Application for funding, including travel funding	Granting body reviews funding proposals; student receives feedback from granting agency, advisor, mentors, and peers.
Create and deliver seminar and conference presentations	Career Development	Student receives oral feedback from advisor, mentors, and peers.
Develop pedagogical skills in the classroom	Teaching	Teaching assistant collaborates with professors and fellow TAs. Evaluation is through CTECs and class visits conducted by the Associate Chair and Teaching Assistant Coordinator.
Search for and applying for jobs	Career Development	Student works with advisors and mentors to create a portfolio suitable for academic job or, of applicable, jobs outside of academia.