University of Wyoming
Department of Mathematics
Graduate Student Handbook

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Contents

Chapter 1

General Information

The term "**graduate assistant**" (GA) refers to either a **teaching assistant** (TA) or a **research assistant** (RA). A TA receives financial support in exchange for teaching an undergraduate math class (or serving in some other way to assist the department's teaching mission). An RA conducts research under the mentorship of a professor who has secured grant funding for the particular research project.

Teaching assistants are required to have 3 office hours per week, two of which are served in the math lab. The amount of time it takes each week to be a TA varies from person to person and depends on the course being taught. A TA should plan on spending at least 18 hours per week on lesson preparation, lecturing, office hours, and grading.

If a TA instructs a 5-credit course one semester, he/she does not teach the next semester.

Research assistants work at the discretion of their mentoring professor. A student's advisor determines the RA's salary, work hours, summer support, and the expectations concerning research progress.

TA stipend checks: The academic year (AY) runs from September through May. A TA receives 9 equal paychecks at the end of each month, September through May. Pay at the PhD level is $15,795 per academic year ($1755/month before taxes). Pay at the MS level is $11,349 per academic year ($1261/month before taxes). The amount of tax paid by international students varies from country to country, depending on the agreement between the United States and the student's country of origin. A tax representative will meet with international students during orientation to go over details concerning their taxes.

Summer employment: TAs receive priority for teaching assignments during the summer. In the early spring, speak to the summer-session coordinator, Jon Prewett, if you are interested in teaching a summer course for extra pay. To find out about other summer jobs, please ask your advisor or the graduate coordinator about what opportunities might be available.

TAs and RAs who are employed in the summer must enroll in one hour of thesis or dissertation research (MATH 5960 or MATH 5980). The university pays the tuition and mandatory fees associated with this credit.

Advising and your PERC number: Each semester, students should meet with their advisors before registering for classes. If your advisor doesn't know how to access your PERC (the PIN that allows you to register), please see the graduate coordinator.

Registering for classes: GAs must register for a minimum of 9 credit hours per semester. Up to 12 hours of tuition and mandatory fees are paid by the assistantship.

Drop deadline: Each semester there is a drop deadline and an add deadline. If a student drops a course before the drop deadline, he/she receives a full tuition and fee refund for the dropped course. If a student adds a comparable number or credits before the add deadline, the two cancel each other out—there is no change in the student's financial account. After the drop deadline, however, only a portion of the tuition is refunded, and a "W" appears on the student's transcript. The amount of the refund decreases as the semester progresses.

Withdrawing from one course and adding another after the drop deadline creates a discrepancy between the amount of tuition that is refunded for the withdrawn course and the amount that is charged for the added course. The mathematics department will not pay this difference in tuition. In other words, if you withdraw from a course and add another one after the drop deadline, you are responsible for the difference in tuition.

Tuition and fees: GAs receive a full tuition waiver for up to 12 credits and a fee waiver for all mandatory fees. Non-mandatory fees are the A & S Computing Fee (~$35) and, if applicable, the International Students Fee (~$45). GAs are responsible for non-mandatory fees (about $75 per semester).

When you register for classes, the university will automatically add tuition and fees to your student account. Please don't panic if you are a GA and your account shows that you owe tuition and fees after the semester starts. The tuition and fee waiver, which comes as part of your assistantship, will not be applied to your account until after the drop/add deadlines. You may receive warnings from the university that you will be dropped from your classes if you don't pay the tuition and fees. Please ignore these threats—you will not be dropped from courses. Eventually the charges on your account will be paid by your assistantship.

Medical insurance: As part of the registration process, domestic students are asked whether they want to purchase medical insurance. (International students are not asked. They are assessed the cost of medical insurance automatically.) Domestic graduate assistants should always answer "YES" to the medical insurance question. By doing so, the cost of medical insurance is put on a student's account and the assistantship will pay for it. Domestic students who are not GAs must decide whether or not they want to purchase medical insurance, using their own funds.

Students with assistantships for spring semester automatically receive medical insurance for summer.

Supplies: The math department provides chalk, dry-erase markers, and other basic office supplies free to GAs. The supplies are kept in the copy room. Please let Vicki know if there are any office supplies you need that you don't see in the cabinet.

Photocopying/printing: Operating the copier is one of the department's biggest expenses. When possible, please scan your materials or make two-sided copies. Please do not use the copier for large personal projects.

Phones: Please be sure to give the graduate coordinator your cell number so you can be reached in an emergency. The math office won't release your number to others without your permission.

To use a campus phone to reach another UW number, dial "6" and then the last 4 digits of the number. For calls off-campus, dial "9" before dialing the complete number.

Fax: You are welcome to use fax machine in Vicki's office, RH 222. The number for receiving faxes is 307-766-6838.

Address changes: Please let the graduate coordinator know if you move or change your phone number. If you have an assistantship, please notify Human Resources of any changes by going to WyoWeb→My Workplace tab→Self Service→Personal Information→Home and Mailing Address.

Security: Call 911 if you see any suspicious activity in Ross Hall. Please be aware that laptops have been stolen from offices in the math department when the office door is left open and no one is inside. After hours, please close the following doors you leave the room: copy room (RH 201), classroom (RH 247), Linux Lab (RH 241), and Emeritus Room (RH 352). Thanks!

Harassment: Harassment consists of any continued remarks or actions that are not appreciated or wanted. We hope that you are never in this kind of situation, but talk to the department head if you have problems.

Graduate student representative: Each fall, the math graduate students elect a fellow student as the grad-student representative. The graduate student representative attends graduate committee meetings (unless topics of a sensitive nature are on the agenda), contacts the committee chair or department head with problems, and organizes the graduate-student seminars.

Graduate student seminars: These weekly seminars are a great way to get to know other grad students, hone your speaking skills, and find out about the research that other math grads are doing.

Seminars: Graduate students are encouraged to attend other seminars sponsored by the math department. The Algebra, Combinatorics, and Number Theory Seminar, and the Analysis and Computational Math Seminar both happen on Tuesday afternoons. Other guest speakers come from time to time to present colloquia.

Chapter 2

Responsibilities of TAs and RAs

2.1 Being a Teaching Assistant

In order for your teaching assistantship to be renewed, you must perform well both as a teacher and as a student. In terms of teaching, this means that you are a responsible and capable teacher. Careful supervision of teaching with extensive advice and guidance will be provided during the first year of teaching and in later years if needed. But don't wait if you know that you are having trouble with a class: Ask for help! Ask one of the faculty who supervised the teaching workshop in August, the course supervisor, faculty or graduate students teaching the same course. The Ellbogen Center for Teaching and Learning can also help; they provide individual assistance as well as a variety of workshops for graduate teaching assistants.

Currently, the teaching load for a graduate student with a fulltime teaching assistantship is one course per semester, ranging from 3 to 5 credit hours. We recognize that there are numerous variables that affect the actual workload associated with any particular class, and these are difficult to measure. The department will keep in mind both past teaching loads and stated preferences when assigning courses.

Our policy has always been that special teaching assignments are possible for special circumstances. A TA may teach extra hours or do extra assignments one semester to be freed up during another.

Teaching assistants are normally required to spend two hours a week in the Math Lab, and to have at least one additional office hour. Occasionally there are other tasks with which graduate students will be asked to help.

The mathematics department believes that it is important to keep the work load for our graduate students within reason, allowing them as much time as possible to devote to their own studies. This means that we expect faculty to consider their colleagues' course work demands so that a student's homework and exams are spread out over the entire semester.

We also strive to keep TA teaching responsibilities at a reasonable level, and are committed to keeping this at one course per semester. Being a graduate student teaching assistant is a full-time job involving both teaching and learning, and we expect that our graduate students will not take on outside jobs during the academic year. This includes working for the community college or accepting additional jobs within the department.

2.2 Starting to Teach

Most new graduate students do not have any experience teaching. As part of orientation week, you will receive advice from both the math department and from the university on how to be an effective instructor. This section and the next offer some additional ideas.

1. <u>Teaching your own section of a course</u>: Concentrate on preparing and delivering effective and engaging classes, whether the instructional format for the day is a lecture, guided discovery, or a group activity. Read the instructional materials that accompany the text and any materials that have been prepared for instructors. Attend instructor meetings, and

chat with your fellow teachers and the course supervisor about your teaching and the course.

This is just the start of your teaching career, and you don't have time to reinvent the wheel with original in-class group work or projects. For now, follow the suggestions of the course supervisor and the syllabus. In time, you'll be better able to create and select your own materials.

It is imperative that you do ALL of the work that you expect the students to do. Don't go to a lab without having done it yourself beforehand. Go through an in-class activity before assigning it; you can then guide students through things that you found difficult or misleading. Enthusiasm and preparedness is the key to your success.

The syllabus and pace of the course are common to all sections in the precalculus courses (Math 1400, 1405, 1450); exams are common exams, and all instructors are involved in making and grading the exams. Calculus I and II have common syllabi and gateway exams during the semester.

Instructors of the pre-calculus courses assign and grade work that comprises part (usually 30%) of the final grade, and they have some freedom in assigning students' final grades. Be prepared to discuss your plans for the in-class portion of the grading when you meet with the course supervisor before classes start. You will distribute a personalized handout and the common course handouts for the class on the first day. Study the common handouts, and clear up all of your questions about the course before your first class.

Meet with the supervising instructor before your first class! Study the syllabus, the student handout, and the material for the first two weeks of lectures. Clear up any questions that you have before the first class. While many of the questions that students ask should be referred to the course supervisor, at issue is the impression you make on students. You should appear knowledgeable about the course and the expectations of the supervising professor. Do not wing a response, think before you speak. Students will appreciate having to wait for an answer if what you offer later is well informed or well presented.

Lectures encourage students to take a passive role; recitations serve to involve students. You can't learn skills for them, and copying your answers to their homework is not exactly student involvement.

2. <u>Your Debut:</u> The first day sets the tone for the semester. Arrive early! Practice with the boards and lights in your classroom. Start learning student names on day one. Students establish patters of absenteeism early; they may not give you a second chance to get organized. Make your expectations clear on the first day. Try to keep your promises: Be available when you say you will be, grade papers in the fashion that you say you will, etc. Encourage individuals to ask for your help or seek the tutoring help available in the Math Lab. Whether you teach a lecture of a recitation, make sure that your students receive a handout that spells out:
    - Course name, number and section
    - Course prerequisites
    - Textbook title, authors, and edition
    - Your name and the supervisor's name, office number
    - Your office hours and Math Lab hours

- Homework policies
- Test schedule and grading policies
- Policies regarding calculators, open books, etc.

Your classroom practices should reflect standard policies and/or be approved by your course supervisor. The number one complaint from students concerns poorly communicated expectations: “He never told us.” Repeat pertinent policies during the course of the semester; no one absorbs all the details the first day.

Don’t sign any forms on the first day of class. If students want to add your class, send them to David Anton (29 Ross Hall) who will check prerequisites and make sure there is room in the class.

<u>Preparations for Class:</u> Plan each class carefully, including the blackboard layout, the sequence of examples, points to emphasize and transitions between topics, examples and activities. Each example in your lecture should have a purpose for being included. The same is true for guided discovery and group work; however, these more student-centered days require you to be more flexible, addressing student issues and ideas without losing your plans altogether.

Recitations are less structured, but also require planning. In recitations, record the requested problem numbers on the board and structure the order in which you address them. You can measure student understanding by asking specific questions, e.g., *Did you see how to use the new technique #5 on page 300? Doesn’t anyone have any questions on problem #23 on page 240? I thought it was somewhat tricky.*

Be conscious of your demeanor and the impression you make on the students.

- Please dress neatly.
- Don’t pace or jam on your hands in your pockets.
- Move toward students to make a point or invite response.
- Lean back on a wall to allow students time to think or to break the tension.

Students will tune out lectures that stray too far from or stick too close to the examples and methods of the book. Consult with the supervisor *before* straying from the text. Read the textbook for *detail.*

There is always some angle on even the easiest of topics! Apparent lack of respect for the worth or difficulty of a particular topic can lead to disaster. Students may misinterpret your behavior and decide that you’re unable or unwilling to help them, or they will take it as an invitation to skip this seemingly unimportant section.

Take notes to class; do not try to memorize a lecture.

Whether presenting a new topic or an exercise, *tell ‘em what you’re gonna do, do it*, and *then tell ‘em what you’ve just done.* Begin a lecture with an overview of the topic to be discussed. Work under the assumption that students have a 15 minute attention span. A student who naps for 5 minutes may feel lost for 30 minutes unless you take short breaks to sum up.

3. <u>Student Participation:</u> Students are afraid that they will stammer, answer the wrong questions, or look foolish. Asking yes/no questions or saying “Are there any questions?” does little or nothing to draw them out. Be prepared to *rephrase* your questions until students are comfortable enough to answer. Be explicit. Asking “Do you have any questions about when to apply the quotient rule?” or “Could someone please describe the role of the second derivative in graphing a function?” is better than asking “Is that OK?” Don’t ask too many questions at once. It’s helpful to ask for **parts** of an answer you seek, e.g., $(x+3)^5 = ?$ *What’s the degree of the dominant term? Can anyone give me one of the terms in the expansion? Etc.* It’s also good to take part of the student’s answer, e.g., “I’ll take the 4, but it’s not 4x.”

   Guided discovery classes and days where students are working in groups are good opportunities to get to know your students better. If they don’t ask a question, then ask them one. You can also praise part of their work, or ask “why” or “what if” questions related to what they’re doing. Group work or lab days ARE NOT days when you can sit back and relax. They are days when you can make big gains with individuals.

   When students do participate, they may ask ambiguous or sweeping questions: “I don’t understand any of this.” Try to quickly ascertain the true nature of the question. Sometimes asking the right question will dispel confusion and find the real problem: “Have you found common denominators?” Lengthy explanations may damage your rapport with students. If an answer is 5, but you want to explain *why* it is 5, at least start by saying 5.

   You will need to establish some form of *question management*. Repeat a student’s question for the whole class, put the question in context and acknowledge the student for asking. At times, you will have to delay graciously or to decline to respond to a student’s questions. In general, a lecture runs more smoothly if you set aside a regular time for homework questions. Sometimes questions lead into your lecture comments, and you can incorporate a response at an appropriate moment or use the questions to introduce a topic. In this case, plan to write relevant material on a part of the board where you can refer to it later.

4. <u>Boardwork:</u> Students’ notes usually contain only what appears on your blackboard (and perhaps only part of it). Don’t skip around on the board; don’t erase what you’ve just written. Don’t simplify by erasing and writing in something new; write the simplification on a new line on the blackboard. Punctuate calculations with appropriate remarks. Write large and legibly, but not so large that you’re forever erasing. Practice any drawings as part of your prep for class! If what you want to present is too detailed to reproduce well on the board, make an overhead transparency or handout.

   Guided discovery days are good opportunities for you to have students at the board, summarizing the points being made or following instructions given by the class. If using a calculator is a key part of a class, you might have a student punching the keys at the overhead projector so that you can write notes on the board, walk around helping the individual problems, or simply test whether your verbal instructions are clear and being given at a reasonable pace.

5. <u>Discipline:</u> No class is expected to tolerate disruptive behavior. Do not ignore bad or *potentially* bad situations for fear that students won’t submit to your authority.

Sometimes simply saying “Is there a question?” to students who are talking during class will be enough.

You have the power to have a student dropped from your class, although you shouldn’t exercise that authority without first consulting with the course supervisor. Do not get involved in public arguments; cut off debate by referring students to the supervisor or by making an appointment outside of class. *Tell your course supervisor about any conflict immediately*. Students may go to the Math Department to complain before seeing their instructors again.

Handling cases of possible academic dishonesty is particularly delicate. **Never accuse a student of cheating!** Try to *prevent* full-fledged cheating. Often, simply asking a student to move during an exam is the best medicine. *If you suspect cheating, document the situation as best you can and discuss it with your course supervisor.* Never leave an examination unattended, and don’t read or do distracting work during an exam. There are University procedures for dealing with cheating, and these should be used in serious cases.

6. <u>Miscellaneous matters:</u> Here are some additional things that will help your course run smoothly.

   Learn student names. Do this as quickly as you can. This will help students feel that you take them seriously and that they are part of the class. It will help make it easier to foster student participation (and deal with disruptive behavior if it occurs).

   Learning names is easier for some people than others; if you have trouble, here are some suggestions: On the first two days of class, call roll both at the beginning and at the end of class, to help fix some names in your mind (explain to the students why you are doing this). Always hand back homework to students individually; don’t just pass around a pile of papers. If one of your students talks to you individually for help, ask them their name if you don’t remember it, and use it in talking to them if you do.

   Post your schedule. Put your schedule, including both your Math Lab hours and your office hours, on your office door. This will help your students to know when you are available; it is also a university requirement.

   Signing university forms. You should never sign forms for students to add a class; send such students to David Anton (the Math Placement Coordinator, Math Lab). You are allowed to sign Drop and Withdrawal forms; many of these come electronically these days. Other situations in which you will need to decide whether or not to approve a student’s request are late drops, and requests for incompletes. Please discuss such situations with the course supervisor or department head before approving such requests. These should only be granted in extreme circumstances. “I am currently failing” is not a valid reason for such requests. Try to make sure that you are being fair to other students in the class who didn’t ask for special consideration.

   If you grant an incomplete, you will be responsible for working with the student so that they can finish the course. Consider carefully what the student will need to do and discuss this with the course supervisor; this information goes on the incomplete form and should be considered a contract with the student.

2.3 Improving as a Teacher

Time spent in your first year on teaching skills will help prevent trouble later. Most of you will be teaching precalculus courses during your first year. A few of you may be given other assignments, including teaching Problem Solving, Calculus, or as a recitation leader for Business Calculus. In all cases the syllabus, text, and course policies will already be determined for you.

Developing your own philosophy of teaching requires study and reflection. It will not come to you overnight, and it will evolve in time. Learning to teach is a lifelong pursuit. One thing is certain, and you may as well start with this: teaching is more than telling, and learning is more than listening.

Reflect on your own classroom experiences. Did you have instructors who asked you to submit projects, work in groups on problems, or participate in class discussions because (sometimes) student ideas influenced how the class developed? Did you have open-ended assignments? Did your instructors use applications to motivate the study of general ideas? Have you taken classes where technologies were an important component to facilitate understanding? If so, then you have had a taste of "reform mathematics."

The people we train in mathematics will use some form of mathematical technology. Because of their portability and price, graphing calculators are often the tool of choice in lower-division service courses such as precalculus and beginning calculus. In Math Lab you may be asked for help on technology, or you may be assigned to teach a course where calculators are heavily used; in either case, you are expected to move out of the calculator stone age. In the long run, mastery of as many technological tools as possible will enhance your chances for future employment.

When you interview for a teaching position you will be asked to define a teaching philosophy, and experience with various types of teaching will help you form one. The art of teaching mathematics is no longer restricted to organizing lecture notes and selecting examples.

2.4 Math Lab

The Math Lab, in Ross Hall 29, is a service to all students, and the department expects you to make every effort to guarantee its continued success. All TA's are assigned lab hours, generally two hours a week. You should schedule one additional office hour, to give students a chance to meet with you privately. Let students know that they can also make an appointment with you at other times.

1. <u>Hours:</u> The Math Lab schedule is available on the department Web site. David Anton is the supervisor, and you and he will set the set the hours that you tutor in the lab.

2. <u>Calculators:</u> For $10.00, students can rent a graphing calculator (TI-83, TI-86, TI-89) for the semester from the math office. Students will be billed if the calculator is not returned at the end of the semester.

3. <u>Technology:</u> Encourage students to use appropriate technology. Ask students struggling with a graph whether they have used a computer or graphing calculator to do such things. When time permits, give students a hands-on demonstration.

4. Managing Your Time: Try to help everyone in *some way* within the first 10-15 minutes. Sometimes you can get a pair of students to work together, or someone whom you have just helped can help the next student with the same question.

   If the lab is busy, call for help!! There will be a list of people to call for help at busy times or when you feel unqualified to help a student efficiently. (These people are referred to as "backups.") The list of backups should be available by the second week of the semester.

   Some questions will stump you for one reason or another. Don't bluff students and don't waste their time. Call for help! Textbooks and syllabi are available in the main office. If you anticipate needing a brush-up, then read ahead! If you were stumped by a problem today, don't be tomorrow. Ask the faculty member/TA who assigned the problem.

   Some students enrolled in upper-division courses will come to lab; you are not obligated to help them. Explain that the lab is for precalculus and calculus students and that they should see their instructor.

5. Gossip and Complaints: Don't fuel student complaints about a course or instructor. Try to be diplomatic and noncommittal, yet supportive of the student. Even if something untoward seems to be happening in the course, in fact, the problem may be a misunderstanding that needs to be clarified. Report what seem to be problems. Perhaps speak to the instructor and describe the situation without naming the student. If this seems inappropriate, see the course supervisor or the department head.

   Whatever you do about such problems, imagine yourself in the instructor's or TA's shoes. Act in the way that you would like someone else to act if the situation were reversed and there were student complaints about your classes or recitations.

2.5 Being a Research Assistant

Research Assistantships differ from Teaching Assistantships in several ways. The most obvious difference is that an RA is paid to help with research instead of teaching. A second difference is that money for RA's usually comes from grants that individual faculty members have received from external funding agencies such as the National Science Foundation, whereas money for TA's comes from a fixed, regular allocation by the Dean of Arts and Sciences. A third difference is that the faculty member in charge of the grant—not the Graduate Committee—has control over the allocation of RA's.

An offer of a research assistantship depends upon an alignment of interests with faculty members who have grants. Most students never work as RA's. If you are one, remember that you receive the stipend in exchange for work related to a grant and that the faculty member who hires you is under some pressure to produce publishable results with your help. Nonetheless, you have the right to reserve some time of your own for course work. Work out explicit understandings about time commitments and expected productivity when you first start working as an RA.

Chapter 3

Getting a degree

3.1 Progress towards a degree:

Although the department cannot guarantee funding beyond the current academic year, it endeavors to maintain financial support for graduate assistants who are making adequate progress towards graduation. A master's student should graduate in two years, and a doctorate student should graduate in five. These timelines conform to a university-wide policy regarding funding limits for teaching assistants. Although research assistants are not necessarily under similar funding constraints, all math graduate students should plan to graduate within the two- or five-year timeline.

To make adequate progress towards graduation, and to fulfill other departmental requirements, the following criteria should be met:

- Completion of at least 9 hours of courses each semester that contribute toward a degree in mathematics, while maintaining an average of 3.0 (B) or better.
- Passing the competency exam in the first two semesters.
- For master's students, establishing a relationship with a research advisor and beginning a thesis project by the end of the second semester.
- For doctoral students who enter the program with a master's degree, establishing a relationship with a research advisor and beginning a dissertation project by the end of the second semester.
- For doctoral students who enter the program with a master's degree, passing the qualifying exam by the end of the third semester.
- For doctoral students who enter the program without a master's degree, establishing a relationship with a research advisor and beginning a dissertation project by the end of the fourth semester.
- For doctoral students who enter the program without a master's degree, passing the qualifying exam by the end of the fifth semester.

3.2 Exam policy:

The following exam policy is in effect for all graduate students entering the program in fall 2012 or thereafter. Students in the program before fall 2012 may choose to graduate under the old exam system or the new one.

1. **Competency examination**: All incoming students (master's and Ph.D.) will be asked to pass an exam in multivariate calculus and linear algebra at the level of upper-division undergraduate courses. The exam will be offered at the beginning of the fall semester and at the beginning of the spring semester. Students may attempt the exam two times and must pass in order to continue to the second year of study.

2. **Qualifying examination (Ph.D. students only):** Ph.D. students must pass an exam known as the qualifying examination. Students will take the exam in the area of their dissertation research (algebra, analysis, or applied mathematics). The exams will be

written by the appropriate departmental research group. Students may attempt the qualifying exam two times.

Ph.D. students with master's degrees at the time of admission must pass the qualifying exam by the end of the third semester. If these students attempt the exam in their first semester, it counts as a "free" attempt. If the exam is passed, it counts as a pass. If the exam is failed, it does not count as one of the student's two attempts. PhD students with master's degrees who do not pass the qualifying exam by the end of the third semester will be asked to leave the program.

Ph.D. students without master's degrees must pass the qualifying exam by the end of the fifth semester. If these students attempt the exam in their first two semesters, the attempts are "free." Exams that are passed during the first two semesters count as passes. Exams that are failed do not count towards the student's two attempts. PhD students who enter the program without master's degrees, and who fail to pass the qualifying exam by the end of the fifth semester, will be asked to leave the program with M.S. degrees.

3. **Preliminary examination (Ph.D. students only):** After completing 30 credits of coursework and submitting a program of study, Ph.D. students are eligible to take the preliminary examination. The prelim consists of a 30-minute presentation made by the student on a topic related to the student's dissertation. The oral presentation is followed by a Q/A session conducted by the student's committee.

   University regulations require that students graduate within 4 years of passing the preliminary exams. The preliminary examination cannot be held less than 15 weeks prior to the final examination.

4. **Final examination (Master's and Ph.D. students):** All students will defend their theses or Plan B papers by giving oral presentations and answering questions from their committees.

   Master's students are expected to complete their final examinations and other graduation requirements by the end their second year.

   Ph.D. students who enter the program with a master's degree are expected to complete their final examinations and other graduation requirements by the end their third year.

   Ph.D. students who enter the program without a master's degree are expected to complete their final examinations and other graduation requirements by the end their fifth year.

Appeals to this schedule can be made to the graduate committee.

The new exam policy applies to all math graduate students, regardless of whether the students are supported by teaching assistantships, grants, scholarships, or personal resources.

3.3 Qualifying exams:

Qualifying exams are offered at the beginning of the fall and spring semesters (twice a year) and are based on the relevant core courses. Past exams are available from the graduate coordinator for scanning or photocopying. Students preparing for exams should study together if possible and contact professors as a group for assistance.

The algebra qualifying exam:

The algebra qualifying exam covers linear algebra and abstract algebra; students are required to show some competency in both of these areas. Within the abstract algebra portion, the theory of groups, rings and fields is the primary focus. However, questions may not be strictly compartmentalized as such: a ring theory question may involve knowledge of groups; a field theory question may require some use of linear algebra; etc.

The grading system favors students who answer some questions thoroughly, above those who write down incomplete solutions to many problems. Most questions require only an understanding of algebra as found in introductory courses and textbooks. The exam often includes a few more advanced questions based on material covered in recent advanced algebra courses (such as Math 5555: Algebra II) to provide some additional choices for students who have recently completed those courses. However, the student is always given more than enough questions on the exam to choose from, so that those who have completed no algebra courses beyond Math 5500 and 5550 can still choose from among several questions on the more basic material. It is always possible to pass the exam with a strong understanding of the content as found in typical good undergraduate textbooks (the content of which, however, is much more than is typically covered in an undergraduate course).

The best preparation for the algebra qualifying exam (for a student currently in, or having taken the graduate algebra sequence Math 5500: Advanced Linear Algebra and Math 5550: Abstract Algebra I) is to obtain copies of recent exams from the Graduate Coordinator, try writing solutions to the exam questions, and to ask a faculty member (preferably one who has recently taught Math 5500/5550) to discuss with them their written solutions.

Linear Algebra

Suggested textbooks:
S. Axler, *Linear Algebra Done Right*, 2nd ed., Springer, 1997.
K. M. Hoffman and R. Kunze, *Linear Algebra*, 2nd ed., Prentice Hall, 1971.
R. A. Horn and C. R. Johnson, *Matrix Analysis*, Cambridge Univ. Press, 1990.
Y. Katznelson and Y. R. Katznelson, *A (Terse) Introduction to Linear Algebra*, AMS, 2007.
P. D. Lax, *Linear Algebra and Its Applications*, 2nd ed., Wiley, 2007.
S. Roman, *Advanced Linear Algebra*, 3rd ed., Springer, 2007.
G. Strang, *Linear Algebra and Its Applications*, 3rd ed., Harcourt Brace Jovanovich, 1988.

Topics:

Vector spaces; bases and dimension; linear transformations and their matrix representations; rank and nullity; trace and determinant; minimal and characteristic polynomials of linear transformations; eigenvalues and eigenvectors; invariant subspaces; dual spaces; real and complex inner product spaces; orthogonal, unitary, Hermitian, normal and positive definite matrices; canonical forms, including diagonal and Jordan canonical forms.

Abstract Algebra

Suggested textbooks:

D. S. Dummit and R. M. Foote, *Abstract Algebra*, 3rd ed., Wiley, 2003.
I. M. Isaacs, *Algebra: A Graduate Course*, AMS, 2009.
B. Hartley and T. O. Hawkes, *Rings, Modules, and Linear Algebra*, Chapman and Hall, 1970.
I. N. Herstein, *Topics in Algebra*, 2nd ed., Wiley, 1975.
T. W. Hungerford, *Algebra*, Springer, 1980.
J. J. Rotman, *The Theory of Groups*, 2nd ed., Allyn and Bacon, 1973.

Topics:
Groups: subgroups; cosets and Lagrange's Theorem; homomorphisms; normal subgroups; quotient groups; isomorphism theorems; symmetric groups; permutation groups; Cayley's representation theorem; permutation actions; automorphisms; conjugacy; Sylow theorems; Jordan-Hölder theorem; simplicity; solvability.

Rings: subrings; ideals; homomorphisms; ideals; quotient rings; integral domains; maximal and prime ideals; polynomial rings.

Fields: subfields and extension fields; using irreducible polynomials to construct extensions; algebraic and transcendental extensions; field automorphisms.

Note: Basic Galois Theory (up to the Fundamental Theorem of Galois Theory) is sometimes covered in Math 5550 and may be an asset, but most exam questions on field theory require only a more basic understanding of field extensions.

<u>The analysis qualifying exam</u>:

Real analysis section

- Preliminaries: elementary set theory, ordering, cardinality, real numbers, metric spaces
- Topology in function spaces: convergence theorems, modes of convergence
- Measures: σ-algebras, outer measures, Borel measures on R^n
- Integration: measurable functions, integration, Lebesgue and Riemann integration, convergence theorems, Tonelli and Fubini theorems
- Decomposition and differentiation of measures: absolute continuity, the Radon-Nikodym theorem, functions of bounded variation, Lebesgue's differentiation theorem
- The L^p Spaces: duality, inequalities and applications

The material is standard and can be found in many texts. Possible texts are:

1. W. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 1976.
2. H. L. Royden, Real Analysis, 3rd. ed., Macmillan, 1988.

3. G. Folland, Real Analysis: Modern Techniques and their applications, 2nd ed., Wiley, 1999.
4. E. Stein and R. Shakarchi, Real Analysis: Measure Theory, Integration and Hilbert Spaces, (Princeton Lectures in Analysis), Princeton U Press, 2005.

Supplemental texts:

- A. Torchinsky, Real Variables, Addison-Wesley, 1988.
- W. Rudin, Real and Complex Analysis, 3rd ed. McGraw-Hill, 1987.
- Taylor, Measure Theory and Integration, Graduate studies in Mathematics, AMS, 2006.
- Wheedon and A. Zygmund, Measure and Integral: An Introduction to Real Analysis, Marcel Dekker, 1977.

Complex analysis section:

- Complex numbers and basic functions: algebraic and geometric properties of complex numbers, limits, continuity, complex differentiation, Cauchy-Riemann equations
- Analytic functions and integration: integrals of analytic functions over paths, Cauchy's Theorem, Cauchy Integral Formula, Liouville, Morera, & maximum-modulus theorems, open mapping theorem
- Sequences, Series and Singularities: convergence of sequences and series, power series, manipulation with power series, Laurent series, singularities and analytic continuation
- The calculus of residues: the residue formula, evaluation of definite integrals, argument principle, Rouche's Theorem, Laplace and Fourier transforms
- Harmonic Functions: definition and examples, basic properties, Poisson formula
- Conformal maps, Schwarz Lemma, Riemann Mapping theorem, Picard's theorems

The material is standard and can be found in many texts. Possible texts are:

1. M.J. Ablowitz and A.S. Fokas, Complex Variables: Introduction and Applications, 2nd ed., Cambridge UP, 2003.
2. E. Stein and R. Shakarchi, Complex Analysis, (Princeton Lectures in Analysis II), Princeton UP, 2003.
3. M. Greene and S. Krantz, Function Theory of One Complex Variable, 3rd ed., AMS.

Supplemental Texts:

- L. Ahlfors, Complex Analysis, 3rd ed., McGraw-Hill, 1979.
- W. Rudin, Real & Complex Analysis, 3rd ed., McGraw-Hill, 1987.

<u>The Applied Mathematics Qualifying Exam:</u>

ODE section:

- Fundamental solution techniques, stability and bifurcation for (systems of) differential eqs.
- Asymptotic analysis; BVPs, IVPs, asymptotic expansions
- Calculus of variations
- Green's functions and solutions of BVP via them
- Integral equations

PDE section:

- Separation of variables
- Existence and uniqueness of solutions for the basic PDEs

- Well-posedness
- Solution of hyperbolic equations (characteristics etc)
- Solution via transform methods

The material is standard and can be found in many texts. Possible texts are:

Textbooks used in Math5400, e.g.:

1. D. Logan, *Applied Mathematics*, Wiley, 3rd edition, 2006.
2. John Ockendon, Sam Howison, Andrew Lacey, and Alexander Movchan, *Applied partial differential equations*, Revised edition, Oxford University Press, Oxford, 2003.

Numerical Methods:

- Round off errors
- Finite differences and Taylor expansions
- Solution of linear systems of equations (Gaussian elimination variations: tridiagonal, general, and sparse matrices)
- Iterative methods (relaxation and conjugate gradient methods)
- Solution of overdetermined systems (least squares)
- Nonlinear equations (root finding of functions)
- Interpolation and approximation (polynomial, Lagrange, Hermite, piecewise polynomial, Chebyshev, tensor product methods, and least squares fit)
- Numerical integration (traditional quadrature rules and automatic quadrature rules)

The material is standard and can be found in many texts. Possible texts are:

1. George Em Karniadakis and Robert M. Kirby II, *Parallel Scientific Computing in C++ and MPI: A Seamless Approach to Parallel Algorithms and Their Implementation*, Cambridge University Press, 2003.
2. John H. Mathews, *Numerical Methods for Mathematics*, Science and Engineering, Prentice-Hall, Englewood Cliffs, NJ (USA), 1992.

   Eugene Issacson and Herbert Keller, *Analysis of Numerical Methods*, Dover.

3.4 Research hours policy:

Research hours are enrolled credits in either Math 5960 (Thesis Research) or Math 5980 (Dissertation Research). Master's students must take 4 hours of Math 5960 in order to graduate.

Teaching assistants and fulltime self-funded students must meet the following criteria before enrolling in either thesis or dissertation research.

Master's students

A. Master's students may take 3-4 hours of thesis research per semester if they have completed all of the following:

   1. The competency exam
   2. The 6 required courses
   3. 1 hour of Professional Development (Math 5800-01)

The remaining 6 hours (2 classes) must be formal coursework in mathematics or a related field.

B. Master’s students may take 6 hours of thesis research per semester when they have completed all the requirements for A (above), and are in their final semester. The remaining 3 hours (1 class) should be formal coursework in mathematics or a related field.

Ph.D. students

A. Ph.D. students may take 3 hours of dissertation research per semester when they have completed all of the following:

1. One qualifying exam
2. The 6 required courses
3. A broadening course

The remaining 6 hours (2 classes) should be formal coursework in mathematics or a related field.

B. Ph.D. students may take 6 hours of dissertation research per semester when they have completed all of the following:

1. One qualifying exam
2. The 6 required courses
3. A broadening course
4. The preliminary exam

The remaining 3 hours (1 class) should be formal coursework in mathematics or a related field.

C. Ph.D. students may take 9 hours of dissertation research when they have completed all the requirements for B (above), and are in their final semester.

Part-time students need to apply for research hours each fall and spring semester. (No application is necessary for summer.)

Requesting and reporting research hours

Before enrolling in research hours, students must submit a request to the graduate committee. A report must be filed at the end of the semester. Please see the graduate coordinator for the necessary forms.

3.5 Program requirements for a master’s degree:

M.S. students have 3 options: 1) writing a Plan A Thesis, 2) writing a Plan B Paper, and 3) taking a 3-course sequence instead of writing a thesis or paper.

Students selecting the Plan A Thesis and Plan B Paper options must:

1. Maintain a 3.0 cumulative GPA.
2. Complete 30 hours of formal mathematics coursework at the 5000 level.
3. Within the 30 hours of 5000-level courses, complete the following courses with a grade of A or B:
    - Math 5200, Real Variables I
    - Math 5230, Complex Variables I

- Math 5310, Computational Methods I
- Math 5400, Methods of Applied Math I
- Math 5500, Advanced Linear Algebra
- Math 5550, Abstract Algebra I

4. Within the 30 hours, pass 1 hour of Math 5800-01, Professional Development.
5. In addition to the 30 hours of 5000-level courses, Plan A student s must complete 4 hours of Math 5960, Thesis Research.
6. Pass the competency exam.
7. Prepare and defend a master's thesis (Plan A) or a master's paper (Plan B).

To write a master's thesis (Plan A), a student must do independent research under the direction of a faculty member. The thesis should describe the research and its results and be written to the standards of the appropriate area of mathematics.

To write a Plan B paper, a student must present an expository paper on a designated subject. Students are guided by their advisor in the subject matter and in the preparation of the paper. A successful paper demonstrates that the student can explain a topic outside of their coursework in a coherent manner using appropriate terminology and notation.

Students selecting the 3-course option (known as the Plan B Course-sequence Degree) will:

Take a sequence of three 5000-level courses instead of writing a paper. The sequence must be approved by the student's advisor and the mathematics graduate committee**.** Two of the courses must be offerings from the math department. The third course can be either a mathematics course (including a reading/topics course) or a course from another department in a related field.

In addition to completing the 3-course sequence, students in this option must:

1. Maintain a 3.0 GPA.
2. Complete 36 hours of formal coursework at the 5000 level.
3. Within the 36 hours, complete with a grade of A or B: Math 5200, 5230, 5310, 5400, 5500, 5550.
4. Within the 36 hours, pass 1 hour of Math 5800-01, Professional Development.
5. Pass the comprehensive exam.
6. Write a short paper and give a presentation on the 3-course sequence.

3.6 Program requirements for a PhD:

1. Maintain a 3.0 cumulative GPA.
2. Teach two semesters of college mathematics.
3. Pass the competency exam within the first year.
4. Pass a qualifying exam.
5. Demonstrate mastery of a tool pertinent to the student's area of study, such as proficiency in reading a foreign language or competency with a mathematical software package. The tool must be approved by the student's Ph.D. committee.
6. Pass the preliminary examination.
7. Write and successfully defend a Ph.D. dissertation. The defense includes a public presentation and an oral final examination.
8. Complete a combination of 72 hours of coursework and dissertation research. Within the 72 hours, a maximum of 12 hours can be at the 4000 level, and 42 hours must be formal courses at the 5000 level. The courses should be

mathematics courses or courses with significant mathematical content, as approved by the graduate committee.

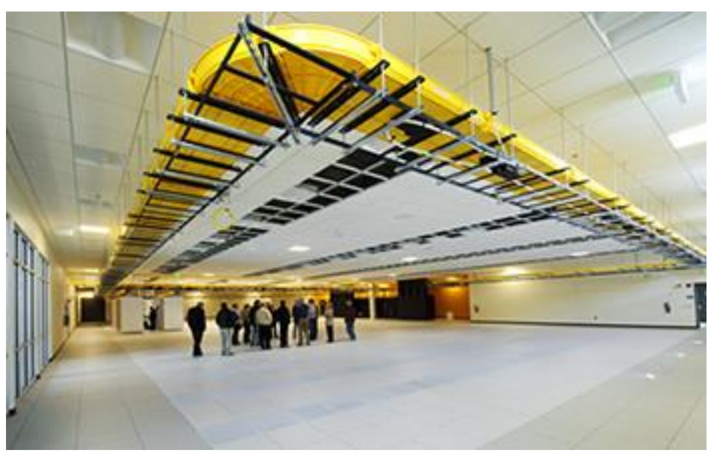
9. Within the 42 hours of 5000-level courses, complete MATH 5200, 5230, 5310, 5400, 5500, and 5550 with a grade of A or B.
10. Within the 42 hours, complete a broadening course as defined by the graduate committee with a grade of A or B.
11. Within the 42 hours, pass 2 hours of MATH 5800-02, Seminars and Colloquia.
12. Within the 42 hours, complete courses distributed in three areas: algebra, analysis, and applied mathematics. The student must take at least two courses in each of two categories and at least one course from the third category. The courses must be passed with a grade of A or B.

Algebra, Combinatorics & Number Theory	**Analysis**	**Applied & Computational Mathematics**
1. Information Theory 2. Cryptography or Computational Number Theory; 3. Modern Number Theory 4. Matrix Theory (5570) 5. Algebra II (5555) 6. Combinatorics (5510)	1. Applied Functional Analysis (5270) 2. Probability and Stochastic Processes 3. Modern PDE (5440) 4. Advanced Functional Analysis (5275) 5. Calculus of Variations & Control Theory	1. Methods of Applied Math II (5405) 2. Scientific Computing II (5340) 3. Mathematical Modeling (5320) 4. Applied Nonlinear Differential Equations (5430)

3.7 Graduate Interdisciplinary Computational Science Minor

The UW Departments of Botany, Chemistry, Computer Science, Geology and Geophysics, Mathematics, Mechanical Engineering, Physics and Statistics collaborate to offer a graduate minor in Interdisciplinary Computational Science (ICS). The ICS minor will help prepare graduate students in science, mathematics and engineering to play leading roles in their profession of choice.

Requirements



The graduate ICS minor is based on the following requirements:

- The student must earn 15 credit hours in specified courses.
- Within the 15 credits, the student must earn at least 12 credits in

graduate level classes (5000).

- Within the 15 credits, the student must earn 6 credits outside of her/his department.
- Only grades of B or better will be accepted for a course counting towards the minor.
- For all students, the 15 hours of coursework will be divided into 9 credit hours of core courses and 6 credit hours of electives.

Course Offerings

The minor is based on the following courses (this list will become more comprehensive and address a broader scope as the program develops.)

Core Courses

- Computational Methods in Applied Sciences I (MATH 5310/COSC 5310), 3 hrs.
- Introduction to High-Performance Computing (COSC 5010), 3 hrs.
- Computational Methods II (MATH 5340/COSC 5340), 3 hrs.
- Computational Biology (BOT 4550/5550), 4 hrs.
- Groundwater Flow and Transport Modeling (GEOL 4030/5030), 3 hrs.
- Computational Fluid Dynamics I (ME 5461), 3 hrs.
- Computational Fluid Dynamics II (ME 5462), 3 hrs.
- Computational Methods in Statistics (STAT 5660), 3 hrs.

Electives

- Analysis of Algorithms (COSC 5110), 3 hrs.
- Advanced Bayesian Statistics (STAT 5680), 3 hrs.
- Bayesian Data Analysis (STAT 5380), 3 hrs.
- High-Performance Computing in Geosciences (course number to be obtained), 2 hrs.
- Mathematics Modeling of Processes (MATH 5320), 3 hrs.
- Molecular Modeling (CHEM 4560/5560), 3 hrs.
- Mathematical and Computational Methods in Physics (PHYS 4840), 3 hrs.
- Mathematical Modeling (MATH 4300), 3 hrs.

Frequency of course offerings

The required courses are taught on a regular basis starting with the Fall 2013 semester. The electives are offered at least once every two years, more frequently when possible.

Organization

The minor is housed in the Mathematics Department, and is overseen by an interdisciplinary advisory committee. Students and faculty who are interested in the ICS graduate minor should contact Dr. Dan Stanescu.

3.8 Finding an advisor:

Students entering the program are assigned an academic advisor to help them with general questions about the program and to advise them on which courses to take each semester. Eventually, students must find a research advisor who will guide their research projects and advise them on how to write a thesis.

Choosing an advisor is a significant decision in your career. Think seriously about what area of mathematics interests you. Attend some seminars, and talk to other students. Feel free to knock on doors and ask faculty members about their research. If you have trouble finding an advisor or have a difficult relationship with your advisor, schedule an appointment with the department head or graduate committee chair.

Your advisor will help you develop a research plan, select your committee, and design a program of study. You can help your advisor by preparing your own tentative list of courses and by thinking in advance about possible committee members. The committee's job is to ensure that your program, written work, and defense are adequate to earn a degree. Think of the committee as a resource. You can submit drafts of written work, seek advice about research, and discuss changes in your program with them.

3.9 Doctoral committees:

A doctoral committee must have at least 5 members, and 1 must be from outside the department. The chair is usually the student's advisor or co-advisor.

3.10 Professional tools:

Ph.D. candidates need to demonstrate proficiency in a professional tool pertinent to their area of study by the time they take their preliminary exams. Examples include mathematical reading knowledge of a foreign language (normally French, German or Russian), or mastery of a pertinent mathematical software package. A professional tool appropriate for a student is chosen by the advisor or committee.

3.11 Dissertations:

A Ph.D. candidate must conduct original research that produces publishable results. The dissertation should show by its form and organization the ability to write in the English language with precision and distinction. Its contents must show maturity of judgment, depth of scholarship, and familiarity with research methods in the field.

As a final step in obtaining a Ph.D., all candidates must participate in a two-hour oral defense of their written work. The student's committee conducts this session, and the first part is open to the public. The candidate should demonstrate an appropriate level of understanding of the work presented and the related field(s).

3.12 Graduation paperwork:

The following series of forms need to be submitted to the Registrar's Office during your program. You can find the forms on the "Graduate Education" link on the university's Web site:

1. Committee Assignment Form: lists your committee members. A thesis committee consists of at least three professors. A dissertation committee consists of at least five. In both cases, one committee member must be from outside the mathematics department.

2. Program of Study: This is a contract between you and your committee regarding what courses you will take in order to graduate. A degree analyst will compare your

program of study with your final transcript, making sure the two agree. Plan A master's students need to include 4 thesis research credits on their program of study.

3. Report on Preliminary Examination for Admission to Candidacy. Indicates whether or not a Ph.D. student has passed the preliminary examination. A student must graduate within four years of passing their prelim. At least 15 months must transpire between passing the prelim and graduating.

4. Anticipated Graduation Date Form. Tells the Registrar's Office that you intend to graduate that semester.

5. Report of Final Examination. Indicates whether or not you have successfully defended your thesis or dissertation.

All paperwork must be submitted to the Registrar's Office by the last day of classes for the semester (or summer session) in which the student is graduating. Please give copies of all signed forms to the graduate coordinator.