This handbook is intended for graduate students in the Department of Mathematics at The University of Alabama. The Department wants their graduate study to be as smooth and pleasant as possible and hopes that this handbook will help to make it so. This handbook will include a large amount of essential and useful information, including specific requirements, departmental policies and procedures, and the general philosophy of graduate work. There are many other sources of information about the University and its graduate programs. For example, further information can be found on the Graduate School website. This handbook was revised May 11, 2015.

Disclaimer

This handbook may not contain all the necessary information. However, every effort is made to ensure the accuracy of information contained herein at the time of publication. The math department reserves the right to make any change, revision or amendment to any part of the Mathematics’ Graduate Handbook deemed necessary or desirable at any time and without prior notice. The Mathematics Graduate Handbook and the information contained herein is published solely for the convenience of students and, to the extent permissible by law the university/math department expressly disclaims any liability which may otherwise be incurred.

Additional information can be found on the following web sites:

Graduate School: http://graduate.ua.edu/

Mathematics Department: http://math.ua.edu/

Graduate Catalog: http://graduate.ua.edu/catalog/

Graduate Student Services: http://gradservices.sa.ua.edu/

Housing and Residential Life: http://housing.ua.edu/

The Graduate Program Director

Initially your graduate advisor will be the Graduate Program Director. You must meet with your advisor to decide on the courses you plan to take each term. Your advisor will also want to discuss with you your overall objectives and how well you are progressing toward them. The Graduate Program Director is familiar with university and departmental regulations and can help you follow them. However, please be aware that it is not your advisor’s job to make sure that you meet all the requirements for your intended degree; that is your responsibility.

You should feel free to see your advisor about any problem that may arise during your graduate work. You may be having trouble with particular courses; you may decide to re-think your decision about what field to concentrate in; you may have visa difficulties. Your advisor will be able to help you take care of any of these problems.
Difficulties that may arise in your teaching duties should be brought to the attention of the Director of Introductory Mathematics who is the direct supervisor of all Graduate Teaching Assistants, and can help you in the same way that a job supervisor can. Are you having trouble assigning grades? Are some of your students disruptive during class? The Director of Introductory Mathematics will help with these sorts of problems.

Degree Requirements

The Mathematics Department offers a Master of Arts and a Doctorate of Philosophy. There is also a joint PhD program in Applied Mathematics with The University of Alabama system campuses at Birmingham and Huntsville.

The requirements listed below are all included in the Graduate Catalog... You should consult the current catalog for complete information about University policies. Incidentally, if University degree requirements happen to change during your stay at the University, you will be subject to the rules that were in force when you first enrolled, not to the new rules. Changes made at the departmental level may work retroactively, depending on the circumstances.

Students with deficiencies in their preparation may remove them by taking the appropriate undergraduate courses at The University of Alabama. For example, if necessary, beginning graduate students should take MATH 587 which is an introductory course in Real Analysis. These courses will not be awarded graduate credits or count toward the number of hours required to earn a graduate degree. The Graduate Program Director will help you determine if you need to take an undergraduate course.

Every graduate student must maintain a grade point average of "B" or better. A student whose grades drop below a "B" average will be placed on academic probation. According to University regulations, a probationary student who cannot return to a "B" average within the next twelve hours of graduate work will be dropped from the program. Furthermore, in order to graduate, at least 75% of the credit hours that are counted as part of the requirement for the degree and approved by the Graduate Advisory Council must be completed with a grade of "B" or better. You must meet with your advisor before each semester, in order to ensure that you are following a suitable program of study. A complete list of courses offered by the university can be found in the Graduate Catalog.

The Graduate School requires all students for an advanced degree to submit an "Admission to Candidacy" form. Master's students can only do this after receiving 12 hours of graduate credit, and PhD students only after passing the Qualifying Examination and having their dissertation proposal approved by their dissertation committee. All students must submit an "Application for Degree" form, which can be found on the Graduate Catalog website, must be approved by the end of the registration period for the semester in which the student expects to graduate. If a student fails to graduate that semester, a new application for degree form must be submitted.

The Master of Arts Program in Mathematics

There is a one-year or three-semester Master's degree program. The Graduate Program Director can provide further information about this program.

Candidates for the Master’s degree in Mathematics can specialize in one of three concentrations: Pure or Applied Mathematics, Mathematics Finance or Mathematics
Education. A total of 30 hours of graduate work is required to obtain a Master's degree in Mathematics. Candidates for the Master's degree may choose one of the following two plans.

Plan I requires successful completion of 24 semester hours of course work, plus a thesis supervised by a graduate faculty in Mathematics. A copy of your thesis or project must be available to each committee member at least two weeks prior to the presentation.

Plan II requires no thesis, but 27 semester hours of courses plus 3 hours of work devoted to a project supervised by a member of the graduate faculty in Mathematics. A copy of the Master's degree approved project or thesis must be provided to Mathematics department.

Students are responsible for finding their own thesis or project advisor. The Graduate Program Director can assist students in the selection of thesis or project advisors.

The following courses do not count toward the Master's degree: Math 502, MATH 504, MATH 505, MATH 506, MATH 507, MATH 508, MATH 509, MATH 551, MATH 552, and MATH 570 AND MATH 592.

Students pursuing a PhD degree in Mathematics can be awarded a Master's degree after they pass their Qualifying Exams, complete 30 hours in graduate coursework and fulfill the core course requirements. A thesis, project or oral exam is not required in this case.

A Master's degree specializing in Pure or Applied Mathematics requires at least 21 credit hours in Mathematics. MATH 591 and MATH 593 do not count toward this 21 hour requirement.

A Master's degree specializing in Mathematics Finance or Mathematics Education requires at least 18 hours in Mathematics. MATH 591 and MATH 593 do not count toward this 18 hour requirement.

Master’s degree students can submit an Admission to Candidacy form after completing at least 12 credit hours of approved courses. Students may fulfill the remaining credit hours by taking other Mathematics courses such as MATH 591 and MATH 593. With the approval of the Graduate Advisory Council, students may take courses in related areas such as Computer Science, Education, Finance, or Physics. Students must pass an oral comprehensive examination covering the thesis or project and possibly coursework.

Students should start their thesis or project work at the beginning of their second year. Projects typically involve writing a major paper, not necessarily original research, in some area of Mathematics, Mathematics Finance or Mathematics Education. A Master's thesis is more formal and usually lengthier than a project. A thesis is typically expository, but based on a substantial body of Mathematics.

**Core course requirements for the Master's Degree in Mathematics**

One course with grade of B or better in each of the following two categories:

Category 1: MATH 571, MATH 573, MATH 674, MATH 587, MATH 580, MATH 681, MATH 565, and MATH 566

Category 2: MATH 510, MATH 511, MATH 512, MATH 520, MATH 521, MATH 522, MATH 541, MATH 542, MATH 554, MATH 555, and MATH 585
One two-course sequence with an average grade B or better from the following seven sequences:

Sequence 1: Algebra - MATH 571 and MATH 573
Sequence 2: Real Analysis - MATH 587 and MATH 580 or MATH 580 and MATH 681
Sequence 3: Topology and Algebraic Topology - MATH 565 and MATH 566
Sequence 4: Numerical Methods - MATH 510 and MATH 511 or Numerical Analysis - MATH 511 and MATH 512
Sequence 5: Optimization - MATH 520 and MATH 521
Sequence 6: Mathematical Statistics - MATH 554 and MATH 555
Sequence 7: Boundary Value Problems – MATH 541 and Integral Transforms and Asymptotic - MATH 542

Research requirements for a Master’s Degree in Mathematics

Plan I: MATH 599 - Thesis Research, 6 credit hours
Plan II: MATH 598 - Non Thesis Project, 3 credit hours

Pure or Applied Mathematics Concentration

In addition to 21 credit hours in Mathematics, Plan I students may choose one elective course from outside Mathematics, subject to the approval of the Graduate Advisory Council. Plan II students may choose two elective courses from outside Mathematics, subject to the approval of the Graduate Advisory Council.

Mathematics Finance Concentration

In addition to the 18 credit hours in Mathematics, Plan I students may choose two of the following courses offered by the Department of Economics and Finance. Plan II students may choose three of the following courses:

EC 570 - Mathematical Economics
EC 513 - Economic Forecast and Analysis
EC 571 - Econometrics or EC 670 - Econometrics
FI 519 – Financial Engineering
FI 520 – Advanced Financial Derivatives
EC 672 - Financial Econometric Modeling

At the student’s request, other courses may be considered for approval by the Graduate Advisory Council.

Mathematics Education Concentration

In addition to 18 credit hours in Mathematics, Plan I students will take MATH 591 - Teaching College-Level Mathematics and one of the following courses offered by the College of Education. Plan II students will take Math 592 – Teaching College-Level Mathematics and two of the following courses:

BER 500 - Introduction to Education Research or MATH 593 - Collegiate Mathematics Education Research
BER 545 – Analysis of Variance in Education
The Doctor of Philosophy Degree in Mathematics

The Doctor of Philosophy degree in Mathematics is intended as a research degree and is awarded on the basis of scholarly proficiency (as demonstrated by course work and the Qualifying Examination) and the ability to conduct independent, original research (demonstrated by the PhD dissertation). Briefly, a successful student must:

A) Complete 48 hours of graduate-level courses with a minimum of 39 hours in Mathematics. (The following courses do not count toward this degree: MATH 502, MATH 504, MATH 505, MATH 506, MATH 507, MATH 508, MATH 509, MATH 551, MATH 552, MATH 570, MATH 586, MATH 587, MATH 591, and MATH 592).
B) Take, in that 39 hours, a maximum of three courses from the following: MATH 500, MATH 501, MATH 522, MATH 532, MATH 537, MATH 585, MATH 588, MATH 574, MATH 571, MATH 593;
C) Pass the PhD Qualifying Examination in two areas of Mathematics
D) Fulfill PhD candidacy requirements
E) Complete at least 24 semester hours of dissertation research
F) Write a dissertation consisting of the student's own original research
G) Give an oral defense of the dissertation results.

For university rules regarding transfer credit, residency requirements and other policies and deadlines, refer to the Graduate Catalog.

Course Work Requirement:

Students must complete 48 credit hours in order to qualify for the PhD. Most of the courses required for a Master's Degree are part of the approved collection. The student's program for the PhD in Mathematics must be approved by the department. Students pursuing a Ph. D. in Mathematics normally must complete the following core course requirements:

One course with a grade of B or better in each of the following categories:

Category 1: MATH 573, MATH 674, MATH 580, MATH 681, MATH 565, MATH 566
Category 2: MATH 510, MATH 511, MATH 512, MATH 520, MATH 521, MATH 541, MATH 542, MATH 554, MATH 555

Three two-course sequences with an average grade of B or better in each sequence from the following sequences:

Sequence 1: Algebra - MATH 571 and MATH 573
Sequence 2: Real Analysis – MATH 580 and MATH 681
Sequence 3: Topology – MATH 565 and MATH 566
Sequence 4: Numerical Analysis – MATH 511 and MATH 512
Sequence 5: Optimization – MATH 520 and MATH 521
Sequence 6: Boundary Value Problems – MATH 541 and Integral Transforms and Asymptotic – MATH 542

Students with deficiencies in their undergraduate background will be advised to take other courses before proceeding with the program above. For example, some students may be asked to complete MATH 587 before taking MATH 580.

Only courses with numbers above 500 are accepted for graduate credit; however, some courses have dual numbers so that they can be taken for either undergraduate or graduate credit. For example, students cannot take both MATH 465 and MATH 565. Also be aware that some 500-level courses may count toward the Master’s degree requirement, but not toward the PhD requirement.

Because a doctoral degree usually requires five years of full-time study, financial support is provided for a maximum of five years. Normally students take three or four courses per semester. If they are employed as Graduate Teaching Assistants (equivalent to a 6-hour teaching load), their minimum course load is 6 hours. However, the total course load plus teaching must be between 12 to 18 hours inclusive.

Students are expected to finish the required core courses above in the first two years of the program (or the first three years, if background deficiencies must be removed). The core course requirement makes up from 18 to 21 of the necessary 48 hours, so students can specialize and broaden their studies.

After their second or third year, students will specialize in the areas pertaining to their dissertation. Students are advised to take at least 12 hours of coursework in their chosen research area. Some students in Mathematics may choose to have a strong minor concentration in some area such as Computer Science, Finance, or Physics. These areas will be beneficial to students who plan to work outside an academic setting. After fulfilling their core course requirements, passing their qualifying exams and completing 39 credit hours in graduate level Mathematics courses, (excluding MATH 502, MATH 504, MATH 505, MATH 506, MATH 507, MATH 508, MATH 509, MATH 551, MATH 552, MATH 570, MATH 586, MATH 587 and MATH 592), students may request approval from the Graduate Advisory Council to take courses from other departments.

Acceptable Progress toward a PhD in Mathematics:

1st Year – Maintain a 3.00 GPA or higher (a 3.40 GPA is required for Graduate Teaching Assistants)
2nd Year – Complete three of the 2-course sequences and core courses with a satisfactory GPA and pass two qualifying exams
3rd Year – Maintain a satisfactory GPA, apply for candidacy, form a Dissertation Committee by the middle of the 3rd year, contact Marcia Black at mblack@ua.edu to reserve a room for your research proposal presentation; obtain approval of your research proposal from your committee and begin dissertation research
4th Year – Complete 48 hours with a satisfactory GPA and report progress to their Dissertation Committee
5th Year – At least one month before defending your dissertation, distribute a copy of your dissertation to committee members. Contact Marcia Black at mblack@ua.edu to reserve a room for your defense.

The PhD Qualifying Examination
The Qualifying Examinations are offered during the last week of June. In case of high demand the Qualifying Exam may also be given during January.

PhD students are expected to take and pass the PhD Qualifying Examination by the end of their second year in the program. The Qualifying Exam attempts to test both the depth and breadth of the student’s knowledge. Therefore, only outstanding students having graduate mathematics work prior to joining the PhD program may request approval from the Graduate Advisory Council to take the Qualifying Exam early.

For the tests, students will choose two subjects from five following subjects and must pass both four-hour long tests; otherwise, a failure status will be reported to the Graduate School. Students who fail the Qualifying Exam may be permitted to retake it once. They may choose any two subjects (both can be different) from the previous ones for the new tests. If a student has passed a test in one subject, he or she may choose any other subject for the second test. Except in special circumstances, one test must be the area of the students’ intended research area.

**The Qualifying Examination in Mathematics**

**Algebra:** Properties of rings: Fundamental aspects of ring and module theory are covered, including Euclidean rings, Principal Ideal Domains, Descending chain condition and Artinian rings, polynomial rings, matrix rings, ascending chain condition and Noetherian rings, finitely generated modules, direct sums of modules, free and projective modules, invariant basis number. Properties of groups: Elementary theory of groups, automorphisms, split extensions, Sylow theorems, examples including dihedral groups, quaternion groups and other groups of small order, p-groups, nilpotent groups, solvable groups and simple properties of such groups, abelian groups, quasi-cyclic groups, finitely generated groups, free groups and their construction, wreath products, groups with the maximum condition or the minimum condition, simple groups.

The Algebra Qualifying Exam will be based on MATH 571 and MATH 573. The material covered in MATH 571 may vary depending upon the interests of the professor who teaches the course. Part II of Dummit and Foote will be covered in MATH 571 together with additional topics from Parts III, IV and V. The Qualifying Exam will have enough problems on it to satisfy the needs of all students, irrespective of who taught the course. The material covered on the Algebra Qualifying Exam can be found in the books of D. S. Dummit and R. M. Foote, *Abstract Algebra*, and J. J. Rotman, *An Introduction to the Theory of Groups*. The algebra exam usually includes definitions, statements and proofs of theorems, examples, and standard exercises. Due to time constraints, not all topics required for the Exam may be covered in the courses.

**Analysis:** Basic concepts of set theory, measurability and Lebesgue measure; measurable functions, Lebesgue integration; bounded, monotone, and Lebesgue convergence theorems for integrals, Fatou's lemma; absolute continuity and functions of bounded variation; Hilbert space, bounded linear operators and their adjoints: Lp spaces, Holder and Minkowski inequalities; Banach spaces, dual spaces, Hahn-Banach Theorem, closed graph theorem, uniform boundedness theorem, and applications; Ascoli's Theorem and applications.

The courses preparatory to the analysis exam are MATH 580 and MATH 681. Most of the above material can be found in Royden's book, *Real Analysis*. Students should be familiar with a substantial collection of examples and counterexamples, and with the proofs of standard theorems. Due to time constraints, not all topics required for Exam may be covered in the courses, in which case students still are responsible for all listed materials.
Topology: Topological spaces, metric spaces, Baire Category Theorem, separation and countability axioms, compactness and related concepts, connectedness and related concepts, continuous functions, Urysohn’s Lemma, Tietze’s Extension Theorem, spaces of functions, Tychonoff’s Theorem, quotient spaces, CW-complexes, homotopy of continuous functions, fundamental group, covering spaces and lifting criteria, singular homology, Hurewitz Theorem, exact sequences, Euler Characteristic, and computations of certain fundamental and homology groups.

Courses preparatory to the topology exam are MATH 565 and MATH 566. Most of the material can be found in the book of Fred H. Croom, Principles of Topology; Chapters 2 through 8 and the first 21 sections in Greenberg-Harper, Algebraic Topology First Course, or Chapters 1 and 2 in Hatcher, Algebraic Topology. This does not mean that the problems on the exam will be taken from this text exclusively; however, a student who demonstrates a reasonably high ability to apply this material will typically pass the exam. Due to time constraints, not all topics required for Exam may be covered in the courses, in which case students still are responsible for all listed materials.

Numerical Analysis: The material covered in the qualifying exam in numerical analysis is based on the core courses MA511-MA512, and includes: Error analysis, solution of linear and nonlinear systems of equations, eigenvalues, interpolation and approximation, least squares problems, numerical differentiation, integration and Richardson extrapolation, initial and boundary value problems for ordinary differential equations, finite difference methods for solving partial differential equations, stability analysis of numerical schemes, basic iterative methods needed for solving elliptic equations, and finite element methods for solving elliptic problems.

The book Numerical Analysis by Richard L. Burden and J. Douglas Faires, Brooks-Cole, Cengage Learning, August 2010, (chapters 2-8, and chapters 10-12) is often used in MATH 511-MATH 512. It covers in sufficient detail all of the material listed above. Background material on linear algebra is assumed: This includes Gaussian elimination and matrix factorization, vector spaces, linear dependence and independence, bases. Due to time constraints, not all topics required for Exam may be covered in the courses, in which case students still are responsible for all listed materials.

Partial Differential Equations and Related Topics
(a) Integral Transforms, Asymptotic and Singular Perturbations: Fourier series, Convergence of Fourier series, Fourier’s theorem, differentiation and integration of Fourier series, partial differential equations of physics heat, wave and Laplace’s equation, classification of the partial differential equations and boundary conditions, the Fourier method, the concept of eigen-values and eigen- functions, solution of both homogeneous and non-homogeneous boundary value problems in rectangular, cylindrical and spherical coordinates, method of eigenfunctions expansion, Duhamel’s theorem, generalized Fourier series, Sturm Liouville theory, Fourier-Bessel series, Legendre polynomials and the associated Legendre functions, uniqueness of solution for the heat and wave equations, Greens functions for ordinary differential equations, d’Alembert’s solution of the wave equation, asymptotic expansions, Laplace’s method, method of steepest descent, method of stationary phase, Fourier and Laplace transforms and inversion formulae and their asymptotics, asymptotic methods of solution of differential equations and the WKB method, singular perturbations and matched asymptotics, the Lindstedt-Poincaré technique, the method of renormalization, the method of multiple scales, the
Krylov-Bogoliubov, Floquet theory, the Mathieu equation, the method of strained coordinates, Whittaker's method, problems with two boundary layers, multiple decks, eigen-value problems with turning points, solvability conditions.


Normally, the two-course sequences are designed to help students prepare for the Qualifying Exam. However, students are responsible for all listed topics although some topics may not be covered in class because of time constraint. The test on each subject is written and graded by a committee consisting of at least two faculty members in the area. The committee will report their assessment to the Graduate Advisory Council.

Copies of some Qualifying Exams are available on the Graduate Resources page of the departmental website; however, questions are not expected to be similar to those in old tests or final exams. Qualifying Exams can have questions on basic undergraduate materials related to the topics of the tests.

PhD Candidacy Requirement

After passing the Qualifying Exam and successfully finishing the core course requirement, students must decide on a major area of specialization and find an advisor in that area. Their major area of specialization should typically be in an area related to one of the subjects of their Qualifying Exam. The Graduate Program Directory will assist them in choosing a dissertation advisor. An appendix to this document lists the current faculty members and their interests. Students must then form a dissertation committee that consists of at least four Mathematics faculty members, with one member being their advisor. In a formal meeting, students must present their dissertation research proposal to the committee with a well-defined plan for carrying out the research. The committee will assess the worthiness of his or her research proposal and approve or disapprove his or her candidacy status. Under normal circumstances, students should fulfill all PhD candidacy requirements by the middle of their third year in the PhD program or by the end of their third year if their deficiency needs to be removed. Otherwise, their financial support will be reviewed by Graduate Advisory Council and may be reduced by 50%.

The PhD Dissertation

After completing the above requirements, students are admitted to candidacy for the PhD degree. Each student must demonstrate a broad knowledge of Mathematics. The Qualifying Exam and the required-curriculum listed courses represent very basic Mathematics. The main objective of a Mathematics PhD student is to become a creative and independent mathematician. Students may still be required to do course work. Much of this should be completed in their main area of specialization, although other courses can be taken in related areas. Initially, the admitted candidates are advised by the Graduate Program Director. Eventually, they will be directed by their advisor. The 24 hours of dissertation research required by the Graduate Catalog represent only a minimum, and there is no guarantee that a
dissertation is finished once this minimum is achieved. Good results are required before one has a dissertation. It is imperative that the dissertation represents original work that can be published in a recognized research journal.

The Dissertation Defense:

Each student is required to have a dissertation defense committee consisting of five faculty members. One committee member must be chosen from outside the Department of Mathematics, possibly from another university. The committee's purpose is two-fold: first, to make useful suggestions about the dissertation; second, to administer a final oral examination; the dissertation defense. Because of the first purpose, the committee should be kept closely informed of the student's progress as he or she works on his or her dissertation research.

Each student is required to give an exit seminar on his or her dissertation about three months prior to the formal defense. All graduate students working in related areas are required to attend these exit seminars. Once the dissertation is written, the candidate must provide copies to his or her committee members, giving the committee at least a month to review the dissertation before the dissertation defense. The oral defense consists of the general presentation concerning the work and a Q&A session with the committee. The committee's questions are not necessarily confined to the dissertation's topic, but may involve related topics. The candidate's advisor can help him/her prepare for the defense.

After having a well-written dissertation, passing the oral defense, and fulfilling all requirements for the PhD degree, the candidate will present his/her dissertation to the Graduate School electronically. There are numerous regulations involving official copies of PhD dissertations. For example, the type of paper, size of margin, etc. are regulated. The Graduate School has publications regarding the preparation of dissertations. Students may note that it may take at least two months to prepare an official copy of a dissertation. LaTeX is the preferred format for mathematics dissertations because the program will format the paper for you.

Exclusion: Each student is expected to make “acceptable progress” toward the intended degree. In the period preceding the Qualifying Exam, “acceptable progress” is determined solely by the courses taken and the grade point average. At the beginning of the fall and spring semesters, the academic committee will review the progress of each graduate student. A student will be dropped out of the PhD program in any one of the following cases:

The student fails to maintain good standing in the graduate program.
The student does not attempt the Qualifying Exam by the end of their second year.
The student fails the Qualifying Exam twice.
The student fails to pass the Qualifying Exam by the end of their third year.

The Doctor of Philosophy Degree in Applied Mathematics

The PhD program in Applied Mathematics is a joint endeavor, conducted with the Mathematics Departments at the University of Alabama campuses in Birmingham and Huntsville. Even if you are not interested in Pure Mathematics, we suggest that you read Section II describing the PhD dissertation. That section discusses some of the philosophy of the PhD degree that is common to both programs. The following are the minimum requirements for the PhD in Applied Mathematics:
A. Complete 42 hours of graduate-level Mathematics courses.
B. Pass the Joint Program Examination.
C. Satisfy the residency requirement of one continuous full-time academic year after passing the Joint Program Examination.
D. Satisfy the language requirement.
E. Complete an acceptable Program of Study which includes at least four graduate-level courses in a minor area of concentration outside the department.
F. Pass a Comprehensive Qualifying Examination associated with the Plan of Study.
G. Complete at least 24 semester hours of dissertation research and defend a research dissertation, the results of which are publishable in a nationally recognized journal.

**Joint Program Examination**

Students will take the Joint Program Examination after the first year of graduate studies. This examination will cover topics from graduate courses in Numerical Linear Algebra; and Real Analysis I and II, and will be administered in two parts: Linear Algebra and Numerical Linear Algebra and Real Analysis.

Topics on which the Joint Program Examination is based:


**Real Analysis:** Lebesgue measure on $\mathbb{R}^1$. Outer measure, measurable sets and Lebesgue measure, non-measurable sets, measurable functions. Positive functions and general functions. Comparison with the proper and improper Riemann integral. Differentiation and integration: Monotone functions, functions of bounded variation, absolute continuity, the fundamental theorem of calculus. Definition of a positive measure. Measure spaces. Measurable functions. The integral with respect to a positive measure. Convergence theorems for positive measures. Monotone and dominated convergence. $L^p$-spaces for positive measures with $p = 1, 2, \infty$, definition, completeness. Product measures, Lebesgue measure on $\mathbb{R}^k$. Fubini's theorem.
The examination may be taken at most twice. On either the first or second attempt, students must pass both parts of the Joint Program Examination by the end of their second year of full-time graduate studies; those who do not will be dropped from the program.

Program of Study

Each Program of Study will stress breadth, depth, and research competence, as well as an understanding of the relationship of the major area to its applications, and will be individualized to meet the student's needs and requirements of the joint PhD program. It will be permissible for a student to complete a Program of Study at one campus, but students will be encouraged to visit campuses other than their own. The three departments will arrange for lecture courses over the T.V. network which links the campuses. Hence, Programs of Study will share the combined expertise of the three campuses.

Programs of study require prior approval by the Joint Program Committee. A Program of Study will consist of at least 54 semester hours at the graduate level, including

A. courses required to prepare for the common core portion of the Joint Program Examination;
B. a major area of concentration consisting of at least six courses in addition to those taken in a, selected so that the student will be prepared to conduct research in an area of Applied Mathematics;
C. a body of support courses giving breadth to the major area of study;
D. an outside minor that is designed to support the major area of concentration and that consists of at least four related graduate courses in an area of science, engineering, operations research, or applied statistics.

Students will take the Comprehensive Qualifying Examination after three years of graduate studies. The examination will cover the program of study, with a written and an oral component, and will be jointly prepared and graded by the student's Graduate Study Supervisory Committee. This will consist of six faculty members: the student's advisor serves as Committee Chairman; two others from the student's home department; one faculty member from each of the Mathematics departments at UAB and UAH; and one from outside the department in the student's minor area. The written component will consist of three parts; two parts will be devoted to the student's major area, and one part will be devoted to his minor area. Three hours will be allowed for each part. The oral portion will cover the entire program of study. Copies of old exams are available on the department's website.

If the judgment of the Supervisory Committee is that the student's performance on the test is not satisfactory, then they may, at their discretion, and without obligation, elect to give the test at most one additional time. The second test, if given, will conform to the above policies for the first test. Students must pass both the written and oral component by the end of their fourth year of full-time graduate studies; those who do not will be dropped from the program.

Language Requirements

The language requirement for each student will be set by the Joint Program Committee with the approval of the appropriate Graduate Dean.

Dissertation Defense
The Graduate Study Supervisory Committee serves as the student's PhD committee. The committee's purpose is two-fold: first, to make useful suggestions about your dissertation; second, to administer a final oral examination the dissertation defense. Because of the first purpose, the committee should be kept closely informed of your progress as you work toward a degree. Once your dissertation is written, you must provide copies to your committee, giving them at least a month to read your work before your dissertation defense. The defense will be oral and may involve both a general presentation from you concerning your work and questions from the committee. The committee's questions are not necessarily restricted to the dissertation, but may involve related topics. Your advisor can help you to prepare for the defense.

Once the dissertation is written, and assuming that all goes well and you are deemed to have passed the oral defense, all requirements for the PhD degree will have been satisfied. After the defense, your dissertation is to be presented to the University through electronic submission. You should take careful note of the endless regulations involving official copies of PhD dissertations. The type of paper is specified; the size of the margins; the work must be bound; etcetera. Please check with the Graduate School for publications regarding the preparation of dissertations. You should be aware that typing and preparing an official copy of a dissertation is not a short-term project; you should probably allow your typist at least two months for the job.

If finances permit, there will be an external examiner who is a faculty member in a mathematics department other than those in the University of Alabama system. This examiner, to be approved by the Joint Program Committee, will have experience in a well-established PhD program, and will have expertise in the area of the dissertation. The examiner will attend the dissertation defense, will advise the Graduate Study Supervisory Committee as to the quality of the dissertation, and will file a report with the Joint Program Committee.

**Employment and Financial Aid**

Financial assistance is available to all graduate students on a competitive basis. The College of Arts & Sciences and the Graduate School have additional merit-based fellowships.

The current graduate stipend is $16,983 for a 9-month teaching assistantship. All additional money, above and beyond the regular graduate stipend is subject to availability of funding, continued good progress towards obtaining a degree and a good employment record. Because a PhD usually requires five years of full-time study, financial support is provided for a maximum of five years.

Each GTA with a 0.5 FTE must be enrolled in a minimum of six and a maximum of twelve credit hours in graduate-level courses (two to four three-hour courses) each semester. A GTA with a 0.25 FTE must be enrolled in a minimum of nine and a maximum of twelve credit hours of graduate-level courses each semester. All GTAs must successfully complete at least six credit hours in each semester to be eligible for the continuation of financial support.

GTAs are paid on a monthly basis on the last working day of the month. All prospective employees must complete an Immigration and Naturalization Service I9 form regardless of citizenship.

The University of Alabama has instituted a mandatory policy that requires a satisfactory background check as a condition of employment. The background check will include the results of a criminal history search, governmental identification number trace (to verify name...
and address), and a national sex offender registry search. This is not a credit check; the report will only be used to evaluate you for employment purposes. Please complete and sign the enclosed Standard release Form for Graduate Employees-Authorization and Release for the Procurement of a Consumer and/or Investigative Consumer Report and return it to us immediately. The report and its contents will be kept strictly private and confidential.

GTAs are required to work in addition to taking courses. The University measures the amount of work expected of students in terms of a 40-hour work per week. A student who is expected to work for 40 hours each week is said to be assigned a 1.0 Full Time Equivalency (FTE); a student working for 20 hours each week has a 0.5 FTE, and so on. In the Mathematics Department, most employed graduate students are assigned a 0.5 FTE, which allows for half of the time to be spent working, and half studying. Workloads vary during the semester, and you may find yourself working 25 hours some weeks and 15 during others.

Any student with a Teaching Assistantship of 0.5 FTE or greater is awarded a full tuition grant, which pays the full amount of that student's tuition. GTAs will never see this money; it just means that they won't have to pay their tuition at the beginning of each semester. GTAs are eligible for a variety of other benefits, including health services, single coverage health insurance provided by the Graduate School, textbooks provided by the Department of Mathematics, and membership in the Alabama Credit Union. For a list of all benefits, refer to the Graduate Assistant Guide.

First year GTAs’ will duties may consist of tutoring or conducting problem sessions for courses taught in large lecture sections. For GTAs teaching their own sections, their normal load is two 3- credit hour courses. Assignments for problem sessions may vary.

Students must earn 18 credit hours of graduate-level Mathematics in order to teach. Once a GTA is eligible to teach, courses are assigned to them by the Director of Introductory Mathematics. For teaching duties, the Director of Introductory Mathematics is their immediate supervisor, and will be happy to help them whenever possible.

Sometimes, however, teaching duties can start to interfere with GTA’s own studies; this is likely toward the end of the semester, when everyone is giving important exams. GTAs must learn to divide their time between their duties as students and as teachers and not allow one responsibility to conflict with the other.

Steps to Continuing Financial Support:

1. Students who were advised to take foundation courses such as Introduction to Real Analysis II and/or Linear Algebra must successfully complete these courses during their first year.
2. Students must complete their core course requirements and pass the Qualifying Exam by the end of their second year.
3. Students must have a dissertation proposal that is approved by their committee by the midpoint of their third year.
4. Students must report substantial progress in their dissertation research work to their committee by the end of the fourth year.
5. Students must maintain a 3.4 GPA or better throughout the 5-year program.

International Students

International students often face different challenges than their American counterparts. For example, visa difficulties can sometimes arise. There are many different ways that this problem
can occur, and you should always speak immediately to the Graduate Program Director if there is any question about your visa.

If your native language is not English, you have the added burden of taking courses and perhaps teaching courses in an unaccustomed language. The university has established certain guidelines and procedures to ease the problems of non-native English speakers. All international students are required to take the Test of English as a Foreign Language TOEFL before being admitted; the Graduate School has established a minimum of 550 pBT or 79 iBT or 6.5 IELTS on the TOEFL or equivalent for admission. These guidelines are not intended as roadblocks or filters for graduate students, but are primarily to protect prospective students. Graduate study in Mathematics is challenging enough without the added problems of trying to cope with an unfamiliar language!

The English Language Institute (ELI) was established on the University of Alabama to help international students master English, and to certify their proficiency in the language. Before being permitted to teach, every non-native English speaker must take and pass the International Teaching Assistant Program (ITAP) test given by the ELI. The program focuses on three main areas of study: pronunciation, teaching methods, and U.S. culture. Every non-native English speaker must complete the appropriate course and pass the Proficiency Exam in a timely manner. Failure to do so will result in the loss of the teaching assistantship.

The ELI gives three kinds of passing grades: "full," "trial full," and "conditional." A student who receives a conditional pass will be assigned to lead problem sessions and tutor undergraduate students. The assistantship is contingent upon the completion of the ITAP course and the appropriate grade on the Proficiency Examination. International students who fail or receive a conditional pass in the ELI examination are required by this department to take courses at ELI and retake the examination at the next opportunity. Failure to do so will result in the loss of the assistantship.

In addition to required courses, ELI also offers a number of non-required short courses that help international students improve their spoken English, writing skills, and cultural knowledge.

Substantial improvement in English skills requirement:

In addition to completing 18 hours of graduate mathematics, international students with teaching assistantships must successfully complete the International Teaching Assistantship Program (ITAP) and pass the ITAP Proficiency Exam before being eligible to teach. The Department of Mathematics expects international students to have a Full Pass on ITAP by May 15 of their first year so that they can perform their expected teaching duties. Otherwise, financial support will not be renewed.

More information can be found at the following links:

English Language Institute: [http://www.eli.ua.edu/](http://www.eli.ua.edu/)

International Student Life: [http://gobama.ua.edu/international/student-life/](http://gobama.ua.edu/international/student-life/)

Graduate Mathematics Faculty and Current Research Interests:

Paul Allen, Algebra
Stavros Belbas, Optimal Control
Jon Corson, Algebra and Topology
Martyn Dixon, Algebra
Martin Evans, Algebra
Jim Gleason, Mathematics Education
Layachi Hadji, Applied & Computational Mathematics
David Halpern, Computational Mathematics, Fluid Dynamics
Wei-Shen Hsia, Optimization
Vo Liem, Topology
Bob Moore, Analysis
Lawrence Roberts, Topology
Roger Sidje, Applied & Computational Mathematics
Min Sun, Optimization
Bruce Trace, Topology
James Wang, Analysis
Pu Wang, Applied Stochastic Processes, Mathematics for Finance
Shan Zhao, Computational Mathematics
Wei Zhu, Computational Mathematics