

PART 9: ADVANCED DEGREES IN MATHEMATICS

The Department of Mathematics offers the degrees of Master of Arts (M.A.) and Doctor of Philosophy (Ph.D.). The regulations and requirements concerning these degrees are established partly by the Graduate School and partly by the Department of Mathematics.

MISSION STATEMENT FOR THE GRADUATE PROGRAM OF THE DEPARTMENT OF MATHEMATICS

The mission of the Graduate Program of the Department of Mathematics is to prepare students for leadership roles in meeting the mathematical needs of our society and to produce professional mathematicians with M.A. or Ph.D. degrees for positions in universities, colleges, industry, governmental agencies, and research centers.

GRADUATE SCHOOL REQUIREMENTS FOR THE M.A. DEGREE

(As abstracted from the 2019-20 online Academic Catalog (catalog.ku.edu).)

Program Time Constraints

Normal expectations are that most master's degrees (excluding some professional terminal degrees) should be completed in two years of full-time study. However, master's degree students are allowed seven years for completion of all degree requirements.

In cases in which compelling reasons or circumstances recommend a one-year extension, the Graduate Division, on recommendation of the department/committee, has authority to grant the extension. In cases where more than eight years are requested, the appropriate appeals body of the school considers petitions for further extensions and, where evidence of continuous progress, currency of knowledge, and other reasons are compelling, may grant them.

Some departments may have more stringent rulings about time restrictions. Students should ask about the policy in effect in the department in which they plan to study.

M.A. and M.S. Degrees

A Master of Arts or a Master of Science degree requires at least one year of graduate work or its equivalent. Stated in terms of hours of credit, the standard master's program requires 30 hours, though some degrees, especially in professional areas, may require as many as 36 or 40 or more. With permission of the department (or in the case of interdepartmental programs, permission of the joint program committee) and of the Graduate Division, it is sometimes possible to complete a 30-hour master's degree with as few as 24 hours if the student enters the program especially well prepared and maintains a superior grade-point average. Work for a master's degree is concentrated in the major area, with only a minimal amount of work (usually no more than 6 hours) that is completed at KU permitted outside the major department. Each master's program must contain a research component, represented either by a thesis (usually for 6 hours of credit) or by an equivalent enrollment in research, independent investigation, or seminars. Within these requirements and well-founded practices, departmental master's programs may be flexible enough to meet the particular needs of individual students.

Master's Final Examinations

A final general examination or defense of the thesis or culminating master's project in the major subject is required of all candidates for the Master of Arts or Master of Science. The degree program and the Graduate Division should ascertain that the graduate student is in good

academic standing (3.0 or higher grade-point average) before scheduling the final general examination or thesis defense.

At the option of the department, the examination may be oral or written, or partly oral and partly written. In some departments, passing a written examination is a necessary preliminary to taking the oral examination by which success or failure is judged.

Master's examinations are administered by a committee of at least three members of the Graduate Faculty. Exam attendance is governed by the [Graduate Student Oral Exam Attendance](#) policy.

The examination is held during the semester of the student's final enrollment in course work. The thesis defense should be held when the thesis has been substantially completed.

The department's request to schedule the general examination must be made on or before the date set by the Graduate Division, normally a minimum of two weeks before the examination date.

Students earning a master's thesis degree must have completed at least one hour of thesis enrollment before the master's degree may be awarded. See the [Graduate Studies website](#) for information and requirements for submitting the thesis electronically.

Master's Student Oral Exam Committee Composition

When the master's student final examination is partly or entirely oral (i.e., thesis defense), the oral portion of the examination must be conducted by a committee which meets the following conditions.

1. Master's committees are composed of at least three voting members.
2. The majority of committee members serving on a master's student oral examination committee must be tenured/tenure-track faculty holding regular or dissertation graduate faculty status in the candidate's department/program of study. Tenured/tenure-track faculty who are appointed as courtesy faculty within the program/department are considered (for the purposes of committee composition) to be faculty of that program/department.
3. Beyond the majority requirement, additional members may hold any graduate faculty status, including regular, dissertation, or special status. This third member can be, but need not be, a member of the candidate's department/program.
4. For approved professional master's degree programs (listed below), the committee may be composed as described above, or any number of the committee members may be professors of the practice, clinical faculty, or research faculty in the department/program. For the approved professional master's degree programs, the committee chair can hold any graduate faculty status.

As long as the conditions above are met, the committee may include more than three members.

The master's committee chair must hold regular or dissertation status. While master's committees are not required to have a co-chair, the student or the committee members may decide to select a co-chair. The co-chair can hold any graduate faculty status.

Substitutions of the committee chair (and/or co-chair) are prohibited after the committee has been approved by the Graduate Division of the school or college. If a committee chair (and/or co-chair) needs to be replaced, the revised committee must be approved by the Graduate Division of the school or college in advance of the exam.

Substitutions of the committee members are permitted as long as the new members hold regular or dissertation graduate faculty status. Special members can be added after the committee has been approved by the Graduate Division of the school or college, but these additions must be approved by the Graduate Division of the school or college in advance of the exam.

Master's Thesis Submission

When the master's candidate has passed the final oral examination and the members of the committee have signed the thesis, a title page and acceptance page with original signatures are to be delivered to the Graduate Division of the school in which the student's program resides so that completion of degree requirements may be officially certified. As a requirement of graduation, the candidate must publish the thesis electronically and pay all applicable fees. Learn more about the electronic submission and publication process [here](#).

Theses will be made available through UMI/Proquest and KU ScholarWorks, unless there is an embargo in place or special circumstances pertain as outlined in the KU Embargo policy.

The student must be the author of the thesis, and every publication from it must indicate that authorship. Practices vary among disciplines—and even among scholars in a given field—as to whether the mentor's name may appear as a co-author, and whether as senior or junior author co-author, on subsequent publication of the thesis (usually revised), or on articles prepared from it. It is expected that clear understandings in individual cases will be established during the apprenticeship period, when ethical practices in publication are addressed within the professional development training of the program.

DEPARTMENTAL REQUIREMENTS FOR THE M.A. DEGREE

A student must fulfill the general requirements of the Graduate School and complete one of the following options.

- (1) Pass one qualifying examination in algebra or analysis, and one in probability/statistics or numerical analysis, and complete 30 hours of 700 or above level courses of which 12 hours are 800 or above.
- (2) Complete 30 hours of courses and pass an oral examination. These courses must include MATH 800, 810, 820, 830, 831. At least 9 of the remaining 15 hours must be from courses numbered 700 or above. These additional hours may include the enrollment credit (a minimum of 2 hours and a maximum of 6 hours) used to fulfill a research component, e.g., enrollment in MATH 896, 899, 990, 993 or advanced courses. An M.A. candidate must demonstrate an ability to communicate mathematics both orally and in written form. In particular, an M.A. candidate not selecting the thesis option (MATH 899) will be expected to write a technical report as part of his or her research component. Also, a candidate will be required to give a short (30 to 60 minutes) presentation of his or her research component in the first part of the oral examination.

- (3) Complete 36 hours of courses numbered 600 or above, complete a research component, and pass an oral examination. These courses must include MATH 727, 765, 781, 790 and 791. At least 24 of the 36 hours must be in courses numbered 700 or above. Course equivalents to MATH 727, 765, 781, 790, 791 may be substituted if approved by the Graduate Studies Committee. An M.A. candidate may, with prior approval of the Graduate Director, substitute up to 9 hours of graduate courses taught in other departments. Also, the 36 hours may include the enrollment credit (a minimum of 2 hours and a maximum of 6 hours) used to fulfill a research component e.g., enrollment in MATH 896, 899, 990, 993 or advanced courses. An M.A. candidate must demonstrate an ability to communicate mathematics both orally and in written form. In particular, an M.A. candidate not selecting the thesis option (MATH 899) will be expected to write a technical report as part of his or her research component. Also, a candidate will be required to give a short (30 to 60 minutes) presentation of his or her research component in the first part of the oral examination.

A proposed program of study must be submitted to the Graduate Director at the earliest feasible time—preferably during the second semester of enrollment. The degree will be awarded only on the basis of an approved program, which can, however be revised.

In exceptional cases a few semester hours of credit (a maximum of 6) may be transferred from another university and counted as part of the semester hour requirement for the M.A. degree. All transferred credit hours are subject to the approval of the Graduate Studies Committee.

A graduate student must maintain at least a B average in his or her graduate courses to be in good standing. The grading system of the Graduate School is explained in Grading System for the Graduate School.

The Application for Degree (AFD) should be submitted online through Enroll and Pay. This is commonly done during enrollment for the session in which the requirements for the degree are expected to be completed.

The written examination required on Option 1 is discussed in the Ph.D. program. (The oral examination required in Options 2 and 3 is scheduled for the individual student by the Graduate Director.) This examination should occur near the time of completion of the course work for the degree. The oral examination will cover the candidate's course work in mathematics (including the thesis or research component). The student should notify the Graduate Director of his or her intention to take the oral examination at least three weeks prior to the time he or she wishes to take this examination. The Graduate School sets deadlines for completion of all requirements, including the oral examination, for August, May or December graduation.

Students choosing Option 2 or 3 must select a member of the senior staff to supervise their research component. A non-thesis research component usually consists of research, independent investigation (e.g. a special reading course in which a mathematical article is researched), or research seminars. A technical report is normally required. Other non-thesis research components are possible and can be designed by the student and the senior staff supervisor with the approval of the Graduate Studies Committee. The thesis usually contains an original exposition of a topic in mathematics rather than an original contribution to knowledge. If a thesis is written, the oral examination will not be scheduled until the thesis is complete. The student must submit four unbound copies of the thesis to the thesis supervisor at least two weeks before the oral examination is to be given so that it can be reviewed by the members of the examining committee before the examination.

Option 3 is designed to meet the needs of a wide variety of students, including those who intend to teach or to work in government or industry after completing their master's degree and those who intend to pursue further graduate study in the mathematical, the natural, or the social sciences. Students electing this option are encouraged to take courses offered by other departments in areas of applied mathematics.

A great variety of course programs is possible under Option 3 and the program selected by a particular student will depend both on his or her educational purposes and on the current availability of courses. In general, the student's program must have a coherent theme and must be appropriate as a master's level program in its particular area of mathematics. While many students under Option 3 choose to focus on an area of pure mathematics, there is great flexibility.

Possible programs include the following:

A student interested in an applied statistics or applied mathematics program can emphasize linear models, time series analysis, numerical analysis, computational statistics, or actuarial science.

A student wishing to earn a master's degree in mathematics with emphasis in mathematics education can choose from a wide variety of pure and applied mathematics courses.

A student interested in future doctoral study in statistics can construct a program including work in both theoretical and applied statistics, together with some training in computing and in probability theory and abstract mathematics.

A student interested in concurrent or subsequent graduate work in any of a variety of areas can select a program leading to an M.A. in Mathematics which would simultaneously deepen his or her mathematics background and help prepare the student for further work in the area of application. For example, it is possible to construct programs which combine mathematics with the following areas:

- (i) operations research with courses in probability theory, mathematical programming and statistics in both the Mathematics Department and the Business School,
- (ii) mathematical biology or biostatistics with courses in probability theory, statistics, real analysis, and differential equations plus courses in genetics and applied statistics in the Division of Biological Sciences,
- (iii) mathematical economics with courses in analysis and differential equations plus courses in theoretical economics,
- (iv) econometrics with statistics and probability courses in the Mathematics Department plus economics courses in the Economics Department,
- (v) quantitative psychology with courses in statistics plus courses in psychological statistics, and
- (vi) a particular area of engineering, with appropriate mathematics courses; for example, classical applied mathematics courses for the area of civil engineering; or control theory, probability theory, and stochastic processes courses for the area of electrical engineering.

An M.A. program with emphasis in yet other areas of the science is, of course, also possible.

THE MASTER'S EXAMINATION.

The Application for Degree (AFD) should be submitted online through Enroll and Pay. This is usually done during enrollment for the session in which requirements for the degree are expected to be completed.

A student who has passed the written qualifying examination for the Ph.D. should let the Graduate Director know his or her wish to receive a Master's degree. A student who wishes to schedule a Master's Oral Examination should see the Graduate Director, who will arrange for an examination time, committee, and see to it that the necessary Progress to Degree forms are executed. The Progress to Degree form must be completed at least three weeks before the date of the examination. In order to graduate in August, May or December, the examination must be taken before the Graduate School deadline.

A student writing a thesis should consult the Graduate School's website for instructions to electronically submit the thesis at <http://graduate.ku.edu/electronic-thesis-and-dissertation>.

Following the examination, the chair of the examination committee completes and signs the Progress to Degree form and returns them to the Graduate Director.

SUMMARY OF MASTER'S REQUIREMENTS

Option	Total No. of Credit Hrs	Course Level	Courses Required	Research Component	Exams
1	30	700 and above At least 12 hours at 800 level or above			Qualifying exams in algebra or analysis <u>and</u> one in probability/statistics or numerical analysis.
2	30	700 and above	800, 810, 820, 830, 831	2-6 hours (896, 899, 990, 993, etc...) Projects	Oral Exam
3	36	600 and above At least 24 hours at 700 level or above	727, 765, 781, 790, 791	2-6 hours (896, 899, 990, 993, etc...) Project or Thesis	Oral Exam or Thesis Defense
GRA/GTA must be enrolled in at least six credit hours in fall and spring. Non GTA/GRA international students must be enrolled in nine hours.					

THE PH.D. PROGRAM

The rules, regulations, and requirements for the doctoral program are somewhat more detailed. Before laying them out in a detail we give an informal summary.

The major checkpoints of one's progress toward a Ph.D. are:

- (i) The departmental written qualifying examinations
- (ii) Selecting an advisor
- (iii) The preliminary examination
- (iv) Coursework requirements before the oral examination
- (v) The research skills and responsible scholarship requirements
- (vi) The comprehensive oral examination
- (vii) The dissertation
- (viii) Additional coursework
- (ix) The final examination

The comprehensive examination follows soon after the passing of the preliminary examination. Before the comprehensive can be scheduled, the preliminary examination must be passed, the research skills and responsible scholarship requirements met, and certain course work required by the department completed.

When the student passes the comprehensive, his or her dissertation committee is established and more specialized individual research activities predominate. Upon the completion of an acceptable dissertation, the final examination is scheduled; its name states its role--the final step towards the degree.

GRADUATE SCHOOL REQUIREMENTS FOR THE PH.D. DEGREE

(As abstracted from the 2019-20 online Academic Catalog (catalog.ku.edu.)

The degree of Doctor of Philosophy (Ph.D.) is the highest degree offered by the university. It is awarded for mastering a field of scholarship, for learning the methods of investigation appropriate to that field, and for completing a substantial piece of original research. In addition to preparing research specialists, the process of earning a Ph.D. shares certain goals with liberal education: putting order into human experience; fostering a love of learning for its own sake; instilling respect for human values; integrating various human powers into a process of creation; and making vital, in many fields at least, a sense of history.

Although the courses and research leading to the Ph.D. are necessarily specialized, the attainment of this degree should not be an isolated event in the enterprise of learning. The Ph.D. aspirant is expected to be a well-educated person with a broad base of general knowledge, not only as preparation for more advanced work but also as a means of knowing how the chosen speciality is related to other fields of human thought.

To give depth and breadth to their doctoral programs, many departments require some work in a minor field or at least an articulated selection of extra-departmental courses. Because of the diversity of the fields in which the Ph.D. is offered, and the variety of needs and interests of

individual students, the degree does not have a specific requirement for a minor. However, the Ph.D. aspirant is encouraged to plan an integrated program, under departmental direction, that includes courses outside the major field.

1. APPLICATION AND ADMISSION

A student who seeks admission to a doctoral program must apply to the graduate degree program and school offering the desired degree. Upon admission, the student is known as an aspirant for the degree and remains so designated until successful completion of the comprehensive oral examination. After passing that examination, the student is designated a candidate for the degree.

2. PROGRAM TIME CONSTRAINTS

Minimum Tenure. The student must spend three full academic years, or the bona fide equivalent thereof, in resident study at this or some other approved university, including the time spent in attaining the master's degree. Resident study at less than full time requires a correspondingly longer period, but the requirement is not measured merely in hours of enrollment. Because a minimum number of hours for the degree is not prescribed, no transfer of credit is appropriate. However, doctoral degree programs take relevant prior graduate work into consideration in setting up programs of study leading to the doctorate.

Maximum Tenure. After being admitted to doctoral programs at KU, students must complete all degree requirements in 8 years. In cases in which compelling circumstances recommend a 1-year extension, the Graduate Division has authority to grant the extension on the written advice of the department and dissertation committee. Students who complete the master's degree at KU and subsequently begin doctoral studies have a maximum total enrolled time of 10 years to complete both degrees. Normal expectations, however, are that most master's degrees (excluding some professional terminal degrees) should be completed in 2 years of full-time study, and both master's and doctorate degrees in 6 years of full-time study. Some graduate degree programs may have more stringent time restrictions. Students should inquire about the policy in effect in the department in which they plan to study.

During any phase of doctoral education, a student in any of the above categories may petition the Graduate Division, through the department, for a leave of absence to pursue full-time professional activities related to the doctoral program and long-range professional goals. Leaves of absence also may be granted because of illness or other emergency. Ordinarily a leave of absence is granted for 1 year, with the possibility of extension upon request. After an absence of 5 years, however, a doctoral aspirant or candidate loses status as such and must apply for readmission to the program and the Graduate Division. Please see the [Leave of Absence](#) policy for more information.

Residence Requirement. Two semesters, which may include one summer session, must be spent in resident study at KU. During this period, the student must be involved full time in academic or professional pursuits, which may include an appointment for teaching or research if it is directed specifically toward degree objectives. Enrollment in approved distance-learning courses offered through KU cannot be used to meet the doctoral residence requirement. The student must be enrolled in a minimum of six credit hours a semester, and the increased research involvement must be fully supported and

documented by the dissertation supervisor as contributing to the student's dissertation or program objectives. Research must be performed under the direct supervision of the major adviser if on campus, or with adequate liaison if off campus.

3. RESEARCH SKILLS AND RESPONSIBLE SCHOLARSHIP

All doctoral students must meet the Research Skills and Responsible Scholarship requirement before proceeding to comprehensive exams. The requirement must include at least two components:

- (a) Every doctoral student is required to obtain research skills pertinent to the doctoral level of research in their field(s).
- (b) Every doctoral student is required to have training in responsible scholarship pertinent to the field of research.

4. COMPREHENSIVE ORAL EXAMINATION

When a doctoral aspirant has completed the major portion of the course work at a level satisfactory to the graduate degree program and school and has met all other program, school and general requirements prerequisite to the comprehensive oral examination, including the research skills requirement as appropriately applied and established for the student's particular program, the degree program must request the Graduate Division of its school to schedule the comprehensive oral examination. The examination may be scheduled provided that at least 5 months have elapsed from the time of the aspirant's first enrollment at KU. Before scheduling the examination, it should be determined that the student is in good academic standing (3.0 or higher grade-point average). The examination request must be submitted in advance of the examination date by at least the period specified by the graduate division, normally a minimum of two weeks. The Graduate Division ascertains whether all pertinent requirements have been satisfied and whether reports of any previously scheduled comprehensive oral examinations have been properly submitted and recorded.

The committee for the comprehensive oral examination must consist of at least five members, all of whom must be members of the Graduate Faculty. Its members are appointed by the Graduate Division of the school or college on the basis of nominations submitted by the graduate degree program. At least one member must be from a department other than the aspirant's major department. This member represents Graduate Studies and must hold either Regular or Dissertation status on the Graduate Faculty. The Graduate Studies representative is a voting member of the committee has full right to participate in the examination. In the case of any unsatisfactory or irregular aspects of the exam or violation of Graduate Studies policy, the Graduate Studies representative shall provide a written report to the Dean of Graduate Studies for consideration of further action. The examination may be scheduled provided that at least five months have elapsed from the time of the aspirant's first enrollment at KU.

The comprehensive oral examination covers the major field and any extra departmental work for which the program wishes to hold the aspirant responsible. For every scheduled examination, the degree program reports a grade of Honors, Satisfactory, or Unsatisfactory. If the aspirant receives a grade of Unsatisfactory on the comprehensive oral examination, it may be repeated upon the recommendation of the degree program,

but under no circumstances may it be taken more than three times. In any case, departments, schools, and the College will determine appropriate minimum intervals between attempts.

5. CANDIDACY

Dissertation Committee: Upon passing the comprehensive oral examination, the aspirant becomes a candidate for the doctorate. If it has not begun before, the traditional, close student-mentor apprenticeship relationship comes into being. The student is expected to learn by both precept and example of the mentor, and often in collaboration. The chosen field of scholarship is explored using acquired research tools. The principles and customs of academic inquiry and the codes of ethics traditional to the various disciplines and professional fields become part of the student's thinking and working.

When the student passes the comprehensive oral examination, the Graduate Division of the appropriate school designates the candidate's dissertation committee based on the recommendations of the candidate's major department. The dissertation committee must consist of at least five members and may include members from other departments and divisions or, on occasion, members from outside the university. All members of the committee must be chosen from the Graduate Faculty, and, in addition, the committee chair must be authorized to chair doctoral dissertations. (In other words, the committee chair must hold Dissertation status on the Graduate Faculty.) A prospective member of the committee from outside the university must have gained appointment as a Special member of the Graduate Faculty before appointment to the committee.

Post-comprehensive Enrollment: Doctoral candidates are required, after passing the comprehensive oral examination, to be continuously enrolled each fall and spring semester in one or more hours of dissertation or programmatically-equivalent coursework (for example, document hours for DMA students) that both moves the student towards degree completion and reflects, as accurately as possible, the candidate's demands on faculty time and university facilities. During this time, until all requirements for the degree are completed (including the filing of the dissertation) or until 18 post-comprehensive hours have been completed (whichever comes first), the candidate must enroll for a minimum of 6 hours each semester.

Post-comprehensive enrollment may include enrollment during the semester or summer session in which the comprehensive oral examination has been passed. If after 18 hours of post-comprehensive enrollment the degree is not completed, the candidate must continue to enroll each semester until all degree requirements have been met. The number of hours of each enrollment must be determined by the candidate's advisor and must reflect as accurately as possible, the candidate's demands on faculty time and university facilities.

6. DISSERTATION COMMITTEE/DISSERTATION

The doctoral candidate must present a dissertation showing the planning, conduct and results of original research and/or scholarly creativity. The purpose of the dissertation is to encourage and ensure the development of broad intellectual capabilities and to demonstrate an intensive focus on a problem or research area. The dissertation itself should be an evident product of the candidate's growth and attainment of the ability to identify significant problems; organize, analyze and communicate scholarly results; and

bring to bear on an area of scholarly or scientific interest a variety of research skills and scholarly or creative processes. The dissertation must show some original accomplishment, but it should also demonstrate without doubt the candidate's potential to make future contributions to knowledge and understanding.

The dissertation is to be a coherent scholarly work, not a collage of separate, distinct pieces. Its unity of theme and treatment may still accommodate several subtopics by demonstrating their relationships and interactions. If previously published material by other authors is included in the dissertation, it must be quoted and documented. Final acceptance of the dissertation is subject to the approval of the dissertation committee. It should be noted that prior publication does not guarantee acceptance of the dissertation by the dissertation committee. The dissertation—or one or more substantial portions of it, often rewritten—is expected to be publishable and indeed to be published.

Both the dissertation research and the dissertation itself are to be completed under the guidance and direction of the committee appointed as described in the Graduate Student Oral Exam Committee Composition policy. Instructions about the proper form of the dissertation may be obtained at www.graduate.ku.edu or from the Graduate Division of each school/college. Candidates and faculty members are reminded that the dissertation is to be a coherent, logically-organized, scholarly document. Because the demands and practices of different disciplines are varied, the format is somewhat flexibly described, and moderate departures from the norm are allowed when justified by the nature of the work or the circumstances of presentation. Any substantial divergence must be approved in advance as prescribed by the instructions, and candidates and faculty members are urged to seek early approval to avoid last-minute disappointments over unacceptable format or reproduction.

7. FINAL ORAL EXAMINATION

Completion of the dissertation is the final academic phase of a doctoral program, culminating in the final oral examination and defense of the dissertation. In all but the rarest cases, tentative approval of the dissertation is followed promptly by the final oral examination. When the completed dissertation, in final draft form, has been accepted by the committee and all other degree requirements have been satisfied, the chair of the committee requests that the Graduate Division schedule the final oral examination. This request must be made in advance of the desired examination by at least the period specified by the Graduate Division (normally three weeks). Upon receipt of a request to schedule a final oral examination, the Graduate Division ascertains whether all other degree requirements have been met and whether reports of any previously scheduled final oral examinations have been submitted and recorded. Upon approval of the request, the final oral examination is scheduled at the time and place designated by the Graduate Division. The final oral examination may be held no earlier than 1 month after the successful completion of the comprehensive oral examination. Departments, programs, schools, or the College may require a longer minimum interval between the oral comprehensive exam and the final dissertation defense.

Doctoral dissertation defenses are considered public events. Therefore, the submission of a request to schedule a final oral examination must allow sufficient time to publicize the examination so that interested members of the university community may attend. Exam date and location information must be published in a news medium as prescribed by the Graduate Faculty. Interested members of the university community are

encouraged to attend these examinations.

As described in the [Doctoral Student Oral Exam committee Composition](#) policy, the committee for the final oral examination must consist of at least 5 members. (These may include the members of the dissertation committee plus other members of the Graduate Faculty as recommended by the committee chair and the department and as appointed by the Graduate Division). At least 1 member must be from a department other than the major department. This member represents Graduate Studies and must hold either Regular or Dissertation status on the Graduate Faculty. Before the examination, the Graduate Division provides a list of responsibilities to the Graduate Studies representative. The Graduate Studies representative is a voting member of the committee and has full right to participate in the examination. In the case of any unsatisfactory or irregular aspects of the exam or violation of Graduate Studies policy, the Graduate Studies representative shall provide a written report to the Dean of Graduate Studies for consideration of further action.

For every scheduled final oral examination, the department reports to the Graduate Division a grade of Honors, Satisfactory, or Unsatisfactory for the candidate's performance. If an Unsatisfactory grade is reported, the candidate may be allowed to repeat the examination on the recommendation of the department.

8. DISSERTATION SUBMISSION AND PUBLICATION

When the candidate has passed the final oral examination and the dissertation committee have signed the dissertation, a title page and acceptance page with original signatures are to be delivered to the Graduate Division of the school/college in which the student's program resides so that completion of degree requirements may be officially certified. As a requirement of graduation, the candidate must arrange for electronic publication of the dissertation and payment of all applicable fees. Information about the electronic submission and publication process is found on the [KU Graduate Studies website](#).

Dissertations will be made available through ProQuest and KU ScholarWorks, unless there is an embargo in place or special circumstances pertain as outlined in the [KU Embargo policy](#).

The student must be the author of the dissertation, and every publication deriving from it must indicate that authorship. Practices vary among disciplines—and even among scholars in a given field—as to whether the mentor's name may appear as a co-author and whether as senior or junior co-author, on subsequent publication of the dissertation (usually revised), or on articles prepared from it. It is expected that clear understandings in individual cases will be established during the apprenticeship period, when ethical practices in publication are addressed within the professional development training of the program.

DEPARTMENTAL REQUIREMENTS FOR THE PH.D. DEGREE

(a) THE QUALIFYING EXAMINATIONS IN MATHEMATICS

(1) The Mathematics Department requires Ph.D. students to pass two qualifying exams: one exam in either algebra or analysis and another exam in either numerical analysis or probability/statistics. In other words, Ph.D. students would choose one of the following four exam options.

- algebra and numerical analysis

- analysis and numerical analysis
- analysis and probability/statistics
- algebra and probability/statistics

The qual clock for students will begin when students are admitted to either the M.A./Ph.D. program or the Ph.D. program. Students must complete the qualifying exam requirement before the start of their fifth semester. Exceptions to this requirement will be granted only in very special circumstances.

Qual Coursework. Ph.D. students must pass MATH 727, MATH 765, MATH 781, and MATH 791 (or corresponding 800 level courses) with a grade of B or better or pass the corresponding qualifying exam. For example, MATH 800 or MATH 810 may substitute for MATH 765; MATH 830 may substitute for MATH 791; MATH 881 or MATH 882 may substitute for MATH 781; MATH 866 may substitute for MATH 727, etc. Any 800 level courses used to fulfill the qual course requirement must be passed with a grade of B or better. The qual course requirement must be met before taking the preliminary exam.

- (2) The qualifying examinations will be given near the beginning of each fall and spring semester. Both must be passed by the beginning of the fifth semester.
- (3) An outline of the topics to be covered in the written qualifying examinations can be found beginning on page 119.

(b) SELECTING AN ADVISOR

A Ph.D. student who has passed both of the qualifying examinations needs to select an advisor (if he or she has not already acquired one) to consult before completing the preliminary examination phase of the Ph.D. program. The Graduate Director will help the student in selecting an advisor. The student in consultation with the advisor must select either a pure mathematics track or applied mathematics track for the Ph.D. and start the process of selecting a broad area of specialization.

(c) DEPARTMENTAL POLICY/PROCEDURE ON CHANGE OF ADVISORS

Rationale: A graduate student may change his/her thesis advisor due to various circumstances, including but not limited to: the advisor leaving KU or retiring; the student's research diverging from the area of expertise of the advisor; or differences between the student and the advisor. Change of advisor is allowed even at a late stage of a student's graduate career.

Policy/Procedure on Change of Advisors: Once a student decides to change advisors, he/she may initiate the following process. The student must inform his/her current advisor and should inform the Director of Graduate Studies (DGS) of his/her intention to change advisors. In the event of disagreement on the part of the current advisor, the issue should be brought to the Chair. A change of advisors must not have any effect on the student's eligibility for GTA or departmental summer support. The Chair/DGS should make every reasonable effort to facilitate the change. The student is encouraged to seek advice from faculty members, peers, et al.

A student may approach and ask a faculty member to serve as his/her new advisor. Prior to making a decision and answering the student, the faculty member may consult the DGS and current advisor of the student for more information if necessary.

Depending on the circumstances, it may be appropriate for the current advisor and a graduate faculty member of the Mathematics Department to serve as co-advisors. In this case, the Mathematics Department should encourage this arrangement and the relevant parties should work out the details.

The student must inform the DGS when a decision on change of advisors has been made. The student must still meet all relevant degree requirements of the University, the College and the Department. In the event that the change of advisor occurs late in the student's graduate career, the student and the new advisor may request a modification of departmental requirements via petition to the Graduate Committee. The Graduate Committee will make a decision with a reasonable effort to facilitate a smooth transition.

(d) THE PRELIMINARY EXAMINATION IN MATHEMATICS

Upon passing the qualifying examinations and selecting an advisor, a Ph.D. student is required by the Department of Mathematics to pass one preliminary examination in the student's area of specialization. The preliminary examination may be written, oral, or a combination of both. A preliminary examination committee of at least three faculty members, including the advisor, will decide on the form of the exam, and give the student an outline of topics and suggested readings. The committee will then design the exam and evaluate the student's performance. A Ph.D. student must pass the preliminary examination by the beginning of the eighth semester.

(e) COURSEWORK REQUIREMENTS BEFORE THE ORAL COMPREHENSIVE EXAMINATION

In addition to the qual course work described in section (a), students in both tracks are required to complete significant course work at the 800 or higher level. This course work serves both to prepare the student for the oral comprehensive examination and to provide a broad background. All courses meeting this requirement must be passed with a grade of B or higher.

Students on the pure track must complete MATH 800, 810, 820 or 821, 830, and an approved course in geometry (e.g., MATH 840, 910, 920 or special topics in geometry).

Students on the applied track must complete MATH 800, 810; one of the sequences 881-882, 865-866, or 850-851; and one of the 840, 850, or 950.

(f) RESEARCH SKILLS AND RESPONSIBLE SCHOLARSHIP

Students must satisfy the following research skills and responsible scholarship requirements.

- (i) To meet the research skills requirement, students must complete an introductory programming language course approved by the graduate committee taken at this or at another university as a graduate or undergraduate. Students may meet the research skills requirement by passing EECS 138 or 168. Alternately,

students may complete a computing project approved by their adviser and the graduate committee demonstrating competence in either a programming language or the use of specialized software that supports the student's research. A copy of the project together with a brief report written by the student summarizing the project and its relevance to the student's research should be endorsed by the student's advisor and submitted to the Graduate Director.

(ii) To meet the responsible scholarship requirement, students must follow the steps below.

- Students need to take an online tutorial offered by the Office of Research and Graduate Studies (e.g., the NSF online tutorial). (1 hour)

- At the beginning of the spring semester a seminar led by a graduate faculty member will be offered to introduce the responsible scholarship topics that are relevant to mathematics. Students must complete the online tutorial prior to attending the seminar. Topics relevant for mathematics include issues related to:
 - (a) Authorship, publication, plagiarism, copyright
 - (b) Peer review, refereeing, grant proposal preparation
 - (c) Professional Practices
 - (d) Conflict of Interest
 - (e) Maintenance of confidentiality
 - (f) Student-Mentor relations and responsibilities.

Seminar participants will receive a list of websites and other resources that include case studies, policies, etc. (2 hours)

- Students will further explore the topics introduced at the seminar by attending three one-hour one-on-one meetings with their adviser during the semester. During these meetings the student and his or her adviser will discuss items (a)-(e) above and the adviser will provide appropriate context for the issues under discussion. The student must write a short report summarizing each meeting. (3 hours)
- At the end of the spring semester, students must attend a concluding seminar and report on what each participant in the semester-long training has learned. The seminar will consist of short presentations by every graduate student followed by a group discussion led by a member of the graduate faculty. (3 hours)

(g) THE COMPREHENSIVE ORAL EXAMINATION IN MATHEMATICS

- (1) Before taking the comprehensive oral examination in Mathematics a student must:
 - (i) Satisfy the Graduate School requirements (See section **Advanced Degrees in Mathematics**, The Ph.D. Program).
 - (ii) Pass both qualifying examinations and qualifying coursework.

- (iii) Pass the preliminary examination.
 - (iv) Satisfy the research skills and responsible scholarship requirement.
 - (v) Satisfy the course requirements.
 - (vi) Select, in consultation with his/her advisor, an advisory committee consisting of the advisor and at least four other graduate faculty members. At least one member must be from another department.
- (2) Normally, the work required to prepare a student for the oral comprehensive examination (and to prepare a student to do research) will take the form of one or more semesters of advanced courses, directed readings, and seminars. In the examination a student will be required to show proficiency in his or her chosen area of mathematics. The subject matter and format will be determined by the student's advisory committee and must be communicated to the student in advance.
 - (3) Per University requirement, a student must take and pass the comprehensive oral examination at least one month before the final examination. (For the department, this means one month must elapse between the successful completion of the comprehensive oral examination and the date of the final defense.) A student who fails the comprehensive oral examination may retake it one time.
 - (4) When a graduate student is ready to take the comprehensive oral examination, the student should arrange for a time and a place agreeable to his or her examination committee (the advisor and at least four other graduate faculty members with at least one member must be from another department). The student's advisor reports the exam schedule to the Graduate Director who will execute the necessary Progress to Degree form. This must be done at least three weeks before the date of examination.

Following the examination, the chair of the examination committee shall complete the Progress to Degree form. The completed Progress to Degree form is returned to the Graduate Director.

(h) THE DISSERTATION

- (1) After passing the comprehensive oral examination, the doctoral candidate focuses on research activity.
- (2) The normal course load for a student working on a dissertation is one course, with the rest of the enrollment in dissertation. Students are strongly encouraged to broaden their background by taking advanced graduate courses in areas other than their specialization or to take graduate courses in new areas.
- (3) During this period, the student should be aware of the minimum and maximum time constraints as described in the section PROGRAM TIME CONSTRAINTS.

(i) ADDITIONAL COURSEWORK

The student must complete four additional courses at the 800 level or above before the Final Examination. Courses numbered 896, 899, 993 and 999 may not be used to satisfy this requirement. We recommend that all coursework be completed before the

comprehensive examination.

(j) THE FINAL EXAMINATION

- (1) When the research for dissertation is completed and the student is writing up the results, the student should obtain the guideline for typing a dissertation from the Graduate School, <http://graduate.ku.edu/etd-formatting-and-working-multimedia-files>.
- (2) The arrangements for the examination should be made at least three weeks before the proposed date of the examination. The examination should be held and the Dissertation should be filed with the Graduate Division of the College well in advance of the date of the conferral of the Degree (See Graduate School Calendar 2019-20).

The committee chair recommends an examining committee and a time and place for the examination. The examination committee must consist of at least five members of the graduate faculty and at least one member must be from a different department. The Graduate Director will execute a Progress to Degree form requesting the examination.

Unbound copies of the dissertation should be made available to the examining committee two weeks prior to the examination.

Following the examination, the chair should complete the Progress to Degree form and return it to the Graduate Director.

OUTLINE OF TOPICS FOR THE QUALIFYING EXAMINATIONS IN MATHEMATICS

- (1) The following is an outline of the topics to be covered in the written qualifying examinations in algebra:

INTEGERS.

1. GCD's.
2. LCM's
3. Unique factorization.

GROUPS.

1. Examples.
2. Subgroups.
3. Normal subgroups.
4. Quotient groups.
5. Homomorphisms.
6. Permutations groups.
7. Structure theorem for finitely generated abelian groups.

RINGS.

1. Examples.

2. Ideals.
3. Quotient rings.
4. Homomorphisms.
5. Euclidean domains.
6. Principal ideal domains.
7. Unique factorization domains.
8. Polynomial rings.

FIELDS.

1. Algebraic extensions.
2. Automorphisms of fields.
3. Transcendence degree.

LINEAR ALGEBRA.

1. Linear algebra. Vector spaces, dual spaces, inner product spaces (including orthonormal bases via Gram-Schmidt), linear transformations, eigenvalues, matrices, including trace, determinant and canonical forms. Operators on finite dimensional space (normal, hermitian, unitary).
2. Integers. GCD's, LCM's, unique factorization.
3. Groups. Examples, subgroups, normal subgroups, quotient groups, homomorphisms, permutations groups, structure theorem for finitely generated abelian groups. Statement and application of Sylow's theorems.
4. Rings. Examples, ideals, quotient rings, homomorphisms, Euclidean domains, principal ideal domains, unique factorization domains, polynomial rings.
5. Fields. Algebraic extensions, automorphisms of fields, transcendence degree.

Most of the material above will be covered yearly in MATH 790-791. References : *Linear Algebra*, Hoffman-Kunze (first nine chapters) and *Abstract Algebra*, I.N. Herstein.

- (2) The following is an outline of topics to be covered in the written qualifying examination in analysis:

ANALYSIS.

1. Metric spaces (rudimentary topology, including compactness; convergence of sequences; Cauchy sequences and completeness; continuous functions between metric spaces, uniform continuity).
2. \mathbb{R} and \mathbb{R}^n in particular (sup and inf for subsets of \mathbb{R} , lim sup and lim inf for real sequences; Heine-Borel theorem and its relatives).

3. Derivative (mean value theorem and Taylor's theorem for real functions on a real interval; derivative as linear map for vector-valued functions on an open subset of \mathbb{R}^n ; inverse function theorem and implicit function theorem for vector-valued functions).
4. Riemann integration for functions on a real interval.
5. Series (standard convergence results for series with constant terms; uniform convergence of sequences and series of functions; results on termwise integration and differentiation; power series).
6. Results on interchange of limiting operations (sums, derivatives, integrals, etc.), and examples to show that such interchange is not automatically valid.
7. Instructive examples generally.

One may expect a considerable portion of this material to be covered in MATH 765-766. References: *Introduction to Real Analysis*, Wade; *Principles of Mathematical Analysis*, Rudin.

- (3) The following is an outline of the topics to be covered in the written qualifying examination in numerical analysis:

Students considering taking the numerical analysis qualifier examination are advised to discuss their preparation with one of the numerical analysis faculty.

NUMERICAL ANALYSIS.

1. Computer arithmetic: floating-point arithmetic, rounding, error propagation, loss of significance, and conditioning.
2. Solution of nonlinear equations: iterative methods (bisection method, Newton's method, secant method), rates of convergence, functional iteration.
3. Interpolation and approximation of functions: polynomial interpolation, Lagrange's and Newton's forms, divided differences.
4. Numerical differentiation and integration: numerical differentiation and Richardson extrapolation, numerical integration based on interpolation, Romberg integration, adaptive quadrature.
5. Numerical solution of initial value problems of ordinary differential equations: Taylor-series methods, Runge-Kutta methods, multi-step methods, consistency, stability, convergence, stiffness, stiff equations, A-stability.
6. Linear algebra: vector and matrix norms, canonical forms for matrices (Schur normal form, singular value decomposition, and Jordan canonical form), conditioning of linear equations, eigenvalues and eigenvectors.
7. Solution of linear systems: direct methods (LU and QR factorization), iterative methods (Jacobi, Gauss-Seidel, SOR), and semi-iterative methods (Krylov subspace methods like conjugate gradients).
8. Computation of eigenvalues: power method, inverse iteration, Rayleigh quotients, QR algorithm.

Most topics are covered in the following two textbooks: *Numerical Analysis*,

Mathematics of Scientific Computing, Kincaid and Cheney, Brooks/Cole Publishing Company, 1996, second edition. *An Introduction to Numerical Analysis*, K.E. Atkinson, John Wiley and Sons, 1988, second edition.

- (4) The following is an outline of the topics to be covered in the written qualifying examination in probability and statistics. Students must pass both parts of the exam at the same time.

PROBABILITY.

1. Probability spaces; conditional probability; independent events.
2. Discrete and continuous random variables; univariate and multivariate probability distributions; special distributions.
3. Expectation and moments of random variables; moment generating functions and characteristic functions.
4. Probability inequalities; modes of convergence for sequences of random variables; laws of large numbers; central limit theorem; Slutsky's theorem.

STATISTICS.

1. Point estimation, concepts and methods; comparison of estimators.
2. Sufficient statistics; completeness; Rao-Blackwell theorem tests of hypotheses; Neyman-Pearson lemma; uniformly most powerful tests; likelihood ratio tests.
3. Interval estimation, concepts and methods; relationships to hypothesis testing and point estimation.
4. Examples of applications.

Most of the material will be covered in MATH 727-728. References: *Modern Mathematical Statistics*, Dudewicz and Mishra; *Probability and Statistical Inference*, Bartoszynski and Niewiadomska-Bugaj; and *Statistical Inference*, Casella and Berger.

SUMMARY OF PH.D. REQUIREMENTS

Track	Qual Courses Required	Courses Required	Exams	Research Skills	Enrollment Hours	Research Component
Pure	727 or Qual in Probability/Statistics 765 or Qual in Analysis 781 or Qual in Numerical Analysis	800, 810, 820 or 821, 830 One of 840, 910, 920 Four additional courses at 800 level or above.* 800, 810	Pass two quals, one in algebra or analysis and one in numerical analysis or probability and statistics by the beginning of the fifth semester.	Responsible Scholarship Training Computer Skills	At least six per semester during two semester minimum residency.	Thesis
Applied	791 or Qual in Algebra (with permission advanced students may substitute corresponding 800 level courses)	One of 850-851 or 865-866 or 881-882 One of 840, 850 or 950. Four additional courses at 800 level or above.*	Preliminary by the beginning of the eighth semester. Comprehensive Oral Final Thesis Defense		18 after oral comprehensive (at least six in the fall and spring and at least three in summer). Continuous enrollment after that.	
<p>GTA/GRA must be enrolled in at least six hours in fall and spring. Non GTA/GRA international students must be enrolled in nine hours. *Courses numbered 896, 899, 990, 993 and 999 may not be used to satisfy this requirement.</p>						

GRADUATE CERTIFICATE IN APPLIED MATHEMATICS

The Graduate Certificate in Applied Mathematics requires four graduate level courses (12 credits) and is designed for students who are currently pursuing a graduate degree in a discipline outside of math to enhance their training in various aspects of applied mathematics. Examples include graduate students from the School of Engineering, Economics, Physics, Biology, Geology, Psychology etc.

The admission requirement for the program is the completion of two math courses at level 600 or above with a minimum 3.0 GPA. These courses can then count towards the 12 credits required for the certificate.

The certificate requires the completion of four courses, at least two of them at the 700 level or above from the following list:

Math 601	Math 750
Math 605	Math 781
Math 611	Math 782
Math 630	Math 783
Math 647	Math 865
Math 648	Math 866
Math 650	Math 881
Math 724	Math 882
Math 725	
Math 727 (or Math 627)	
Math 728 (or Math 628)	

Interested graduate students can apply during the semester that they are completing the last course required for the certificate or earlier.

TERM LIMITS FOR APPOINTMENTS FOR GRADUATE TEACHING ASSISTANTS

The University of Kansas, Lawrence, has established outer limits on appointments for Graduate Teaching Assistants (GTAs) as specified below. Summer appointments are excluded from term limit calculations. No term limits established by the university or one of its departments, programs, professional schools, or the College constitutes a guarantee of funding for that amount of time. (<http://policy.ku.edu/graduate-studies/appointment-limit-GTA>)

In accordance with the provisions of the [Memorandum of Agreement \(MOA\)](#) between the University of Kansas, the Kansas Board of Regents, and the Graduate Teaching Assistants' Coalition, American Federation of Teachers -- Kansas (GTAC), a GTA who has exhausted the semester limits may be considered for appointment as a lecturer.

Program-Specific Requirements:

Departments, programs, professional schools, and the College may establish shorter term limits for GTAs, as appropriate. Any such limit shall be codified in writing in the program's graduate handbook, the Academic Catalog, and/or the university's Policy Library and shall take precedence over the university's maximum limit.

Maximum Durations within a Single Department:

- A student who is admitted to a graduate degree program to obtain only a master's degree is limited to six (6) semesters of GTA appointments.
- A student admitted to pursue only a doctorate or admitted to pursue more than one degree in a single department is eligible for up to a total of sixteen (16) semesters as a GTA. **The Mathematics Department's policy for GTA maximum limits for a Ph.D. degree is twelve (12) total semesters. Exceptions may be granted by the Department Chair.**
- A KU student may not serve more than sixteen (16) semesters as a GTA, except as described under "Clean Slates" below.

Students who have exhausted the University maximum time to complete a degree are not considered to be making [satisfactory academic progress](#). As a result, they are not eligible to serve as GTAs, even if a time-to-degree extension is granted. In exceptional circumstances, departments may petition for eligibility to serve as a GTA during a time-to-degree extension using the petition process described below.

Clean Slates for Students Pursuing Degrees in Multiple Departments:

When a student is seeking graduate degrees in two or more departments, they may be eligible for full funding from each, in accordance with the per-department maximum durations above. (e.g., A student who works as a GTA for six (6) semesters while pursuing a master's in one department may, at the discretion of the new department, work for up to sixteen (16) additional semesters as a GTA, should they choose to pursue a degree in a different department.)

Students who return to the same department after time away (e.g., voluntary discontinuation, Leave of Absence, or break in enrollment after a completed Master's degree) will not have their eligibility reset to a clean slate.

In determining whether a person has met the limits described here, **all** semesters of GTA funding for a specific degree program shall be counted, regardless of which department hired the student as a GTA. When a student pursues two funded degree programs in different departments, the maximum limits will be calculated separately for each department.

Petitions:

In exceptional circumstances, a department or program may, with the written support of the appropriate professional school or College, petition the Dean of Graduate Studies for an exception to the GTA term limits. Petitions may be granted when it is in the best **academic** interest of the student to extend the term limits or allow appointment as a GTA during a time-to-degree extension.

If a student has exhausted six (6) semesters of GTA employment prior to a change from a doctoral program to a master's program in the same department, the department may petition for additional semesters of GTA funding to support writing and degree completion, as appropriate.

EXCLUSIONS OR SPECIAL CIRCUMSTANCES:

This policy does not apply to summer-session GTA appointments.

Semesters in which a student's sole appointment was as a Graduate Research Assistant (GRA) or a Graduate Assistant (GA) do not count against the GTA's term limits.

All GTA appointments are made pursuant to the provisions of the [MOA](#).