GRADUATE STUDENT HANDBOOK

NEW VERSION

For students who have started the program in Fall 2015 or later

Effective beginning Fall 2015

Revised July 15, 2016

DEPARTMENT OF MATHEMATICS

MICHIGAN STATE UNIVERSITY

This handbook is intended to provide new and continuing graduate students in the Department of Mathematics at Michigan State University with essential information for the smooth and successful completion of their graduate program. The degree requirements listed apply to you. It is your responsibility to make sure that they are met. If you have any questions about the requirements, see your advisor or the Director of Graduate Studies. If you have a question not answered here, feel free to come to the Office of Graduate Studies, C-213 Wells Hall, for help.

This handbook contains the revisions to the graduate program effective for students who begin in Fall 2015 or later. Students who began their studies in a semester previous to Fall 2015 are governed by the regulations in the older version of this handbook.

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I. PROGRAM OVERVIEW

A. How to Apply

1. MSU Graduate Application at http://grad.msu.edu/apply.
2. Application to the Department of Mathematics, which you complete by logging into http://www.admissions.msu.edu/gradportal using your applicant ID and password issued when you completed the MSU Graduate Application.
3. Three letters of recommendation are required and these are included in the Graduate Portal also. There is a place for you to list the name and email of your recommenders and they will be contacted and asked to upload a letter for you.
4. Download and fill out the Math / STT Courses form. This form should contain the Math and Statistics Classes you have (or will have) taken at the Junior, Senior, or Graduate level. You can download the form here . Once you have it downloaded, fill it out and upload it through the Graduate Portal)
5. Official transcripts of all college work (undergraduate and graduate), including diplomas and certificates. These are to be sent to our Department directly from the school(s) which you attended.

   Effective Spring 2015, MSU will require all incoming ADMITTED students pursuing degrees or who have earned degrees from universities in China to submit a verification report through the China Academic Degrees and Graduate Education Development Center (CDGDC) for their final bachelor degree transcripts. Please read more under: http://grad.msu.edu/CDGDC

   Our address is:

   Graduate Office
   Department of Mathematics
   619 Red Cedar Rd. Room C213
   Michigan State University
   East Lansing, MI 48824

There is no need to send more than one transcript. We will forward the original transcript to the Office of Admissions.

6. GRE Scores - The three standard sections of the GRE, verbal, quantitative, and analytic are required for admission. The GRE subject test in mathematics is required for applicants who want to be considered for teaching and research assistantships or for fellowships.
7. 7. TOEFL Scores (International Students Only) - Applicants for whom English is not their primary language are required to submit TOEFL (Test of English as a Foreign Language) or IELTS (International English Language Testing System) scores. Please see requirements for scores here: https://grad.msu.edu/sites/default/files/content/apply/englangpro.pdf

Applications are accepted for Fall Semester only. We do not accept applications for Spring or Summer Semester.

You will be able to check your application status through the Graduate Portal found at http://www.admissions.msu.edu/gradportal

For any questions that you might have please email grad@math.msu.edu

B. Important Websites - More information is available at the following websites:

The Graduate School Home Page:
http://grad.msu.edu
Application & Request Information:
http://admissions.msu.edu/Apply.asp
Mathematics Department Home Page:
http://www.math.msu.edu
Graduate Programs in Mathematics Department:
https://math.msu.edu/graduate/
Graduate Student Rights and Responsibilities:
http://splife.studentlife.msu.edu/graduate-student-rights-and-responsibilities

Graduate Employees Union @ MSU Contract:
http://geuatmsu.org/geu
Guidelines for Integrity in Research and Creative Activities:
https://grad.msu.edu/research
Responsible Conduct of Research Training:
https://grad.msu.edu/researchintegrity

Guidelines for Graduate Student Advising and Mentoring Relationships:
https://math.msu.edu/graduate/files/MTH_RCR_training.pdf

II. GENERAL INFORMATION FOR ALL GRADUATE STUDENTS

A. Advisors

When admitted, a student is assigned a temporary academic advisor. The advisor will help the students with academic matters. The advisor must be consulted at the time of first enrollment to plan a program of study for the entire year. Each spring semester the student must meet with the advisor to plan a program for the following year. All changes must have the approval of the advisor. Students can request the change of advisors when a more suitable advisor or the dissertation advisor is found.

B. Academic Standards

The minimum grade level at which course credit is awarded is 2.0. The minimum standard for a degree is a 3.0 grade point average. The accumulation of grades below 3.0 in more than three courses (of three or more credits each) or deferred grades in more than three courses (of three or more credits each) automatically removes the student from candidacy for the degree. An accumulation, in excess of four courses, of a combination of grades below 3.0 and deferred grades will also remove the student from candidacy for the degree. A student who fails to meet the standards for any program may be required by the graduate director or the dean to withdraw at the end of the semester.

C. The Graduate Studies Committee

The Graduate Studies Committee consists of five faculty members and is chaired by the Director of Graduate Studies, who is appointed by the chairperson of the department. Each year a faculty member is elected to serve a two year term. Two faculty members are appointed by the chairperson each year. The Committee is responsible for, among other things, admission of students to the various graduate programs and appointment and reappointment of graduate assistants.

The two student members are elected by the graduate students and serve one-year terms in an advisory capacity to the committee.

D. Integrity in Research and Creative Activities

MSU is committed to creating an environment that promotes ethical conduct and integrity in research and creativity. Every student and their faculty advisor must read and understand the document Guidelines for Integrity in Research and Creative Activities (see the Important Websites on page 3). The University views misconduct in research as the most serious violation of University policy. Criteria for dismissal from the graduate program due to unethical or dishonest behavior is also described in this document.

In order for students to become familiar with responsible conduct of research, the department requires our graduate students to complete the necessary training. For details on the Responsible Conduct of Research Training (see the Important Websites on page 3)

E. Judicial Structure

When there are conflicts between a graduate student and his or her faculty advisor or Guidance Committee, including those that may require a change in the student's Major Professor, the following procedure should be followed.

1. The departmental Graduate Director should be consulted, and hopefully an informal resolution is possible.
2. If such a resolution is not possible, a meeting should be set up with the conflicting parties and the Graduate Studies Committee. The Committee will attempt to resolve the conflict in keeping with the policies of the Department and University including the *Guidelines for Graduate Student Advising and Mentoring Relationships* (see the **Important Websites** on page 2-3).
3. If a student remains unsatisfied with the outcome of those conversations, the student may submit a written request to the Department Chairperson for a grievance hearing. The letter must state the specific nature of the complaint or remedy that the student seeks as an outcome of the hearing.
4. Upon receiving a request for a grievance hearing, the Department Chair forwards the letter to the Mathematics Program Hearing Board. The Hearing Board, is governed by rules set forth in the document "Graduate Student Academic Grievance Hearing Procedures For the Mathematics Graduate Program" https://www1.math.msu.edu/graduate/files/MTH_Grad_Grievence_2.pdf
5. If the student prevails at the hearing, the Department Chair will implement an appropriate remedy to accommodate the student. If the faculty member(s) prevails at the hearing, the student may file a request to appeal the Mathematics Program Hearing Board's decision to the College of Natural Science Hearing Board (see the document *Graduate Student Rights and Responsibilities* on the **Important Websites** on page 2-3).

The University Ombudsman is available to assist students, instructors and hearing boards through every stage of the grievance process. The Office of the Ombudsman can be consulted to determine the process for resolution at the Departmental, College or University level (https://msu.edu/~ombud/).

F. Student Rights and Responsibilities

Michigan State University is committed to maintaining a learning and working environment for all students, faculty, and staff that is fair, humane, and responsible – an environment that supports career and educational advancement on the basis of job and academic performance. The University is a community of scholars and all graduate students are expected to conduct themselves in a civilized and scholarly manner.

The principles of truth and honesty are fundamental in a community of scholars. The University expects students to honor these principles and to protect the integrity of the University grading system.

No student shall knowingly, without proper authorization, procure, provide, or accept any materials which contain questions or answers to any examination or assignment to be given on a subsequent date.

No student shall, without proper authorization, complete, in part or in total, any examination or assignment for another person.

No student shall, without proper authorization, knowingly allow any examination or assignment to be completed, in part or in total, for the student by another person. No student shall plagiarize or copy the work of another person and submit it as his or her own.

It is the responsibility of each student in each course to scrupulously follow the policy on external assistance in examinations and in problem sets that is described by the instructor at the beginning of the semester.

Specifics of student's rights and responsibilities are contained in the document *Graduate Student Rights and Responsibilities* on the **Important Websites** on page 2-3).

G. Annual Evaluation

When a student is admitted into our program, it is expected that they progress towards the degree requirements in a timely fashion.

To assist in the evaluation progress, each student is required to file an annual progress report in early March. The chair of the guidance committee, the dissertation advisor, or the student's initial academic advisor must sign the progress report and may wish to supply written comments at that time. The student can then add a written response to the professor's comments. A copy of the progress report and evaluation will be kept in the student's departmental file and can be accessed by the student or any member of the faculty. The student will meet annually with the Director of Graduate Studies to discuss his/her annual report and his/her progress towards the advanced degree before the end of March.

If a student is not making timely and reasonable progress towards his/her degree in terms of completing coursework or taking the necessary exams, within fifteen days following their annual meeting with the Director of Graduate Studies, the student should receive a letter from the Director specifying the

deficiencies and describing the expected steps, with a timetable, to get back in good standing. The student may wish to respond in writing if they disagree with the deficiencies listed or with the steps and timetable for remediation. Any responses will become part of the student's file.

It is a disservice to permit a student to continue towards the advanced degree without necessary qualifications, a high level of motivation, commitment, and aptitude. Judgment regarding retention is made by the student's guidance committee or dissertation committee. The committees may consult the Director of Graduate Studies and the department chairperson. If a majority of the guidance committee decides that a student lacks such standards, he/she may be asked to withdraw from the program according to the procedures as defined in the document *Graduate Student Rights and Responsibilities* on the **Important Websites** on page 2-3).

H. Enrollment

The University stipulates that a minimum of four students is needed before a graduate level course can be offered. Therefore, all graduate students must enroll for each subsequent semester during the enrollment period in the previous semester. Courses with fewer than four students enrolled will be canceled.

I. Seminars and Colloquia

Throughout the academic year, the department issues a weekly bulletin announcing seminars and colloquia being held that week. These bulletins are e-mailed to faculty and students and a copy is posted on the web. Participation in seminars and regular attendance at colloquia are strongly recommended.

III. MASTER'S DEGREE PROGRAMS

The Department of Mathematics welcomes application to the graduate Master's degree program: Master of Science in Industrial Mathematics. The degrees Master of Science in Mathematics, Master of Science with Concentration in Applied Mathematics are available only to students currently in good standing in a PhD program at MSU. The requirements for the various master's degrees are as follows. (The requirements for the Master of Arts for Teachers are currently being reviewed.)

A. Master of Science Degree in Industrial Mathematics

The goal of Master of Science in Industrial Mathematics program is to produce generalized problem solvers of great versatility, capable of moving within an organization from task to task (Visit http://www.math.msu.edu/msim for more information). The graduate will have studied not only the standard mathematical and statistical tools, but also the basic ideas of engineering and business, and will have received training in project development and in modes of industrial communication. The degree requires 36 credits of coursework, the successful completion of the Certificate in Project Management, and the successful completion of an oral master's certifying examination on the student's portfolio of completed projects. The program is for students planning careers in business, government or industry.

Requirements:

Both of the following core courses in industrial mathematics (normally taken during the first year):
MTH 843 Survey of Industrial Mathematics (Fall, 3 credits, standard lecture course).
Visit http://www.math.msu.edu/Academic_Programs/graduate/msim//#MTH843 for course description.
MTH 844 Projects in Industrial mathematics (Spring, 3 credits, tutorial, term project).
Visit http://www.math.msu.edu/Academic_Programs/graduate/msim//#MTH844 for course information.
For details of **additional course work** requirements, visit:
http://www.math.msu.edu/Academic_Programs/graduate/msim/

As well as participate in:

Certificate in Program Management: This requires completion of PHM 857 Project Management, covering such topics as formal project management culture, principles, knowledge areas, and terminology. It will normally be undertaken during the first year of enrollment as a "not-for-credit" option. Certification will also require participation in Industrial Mathematics-specific discussion sessions. After completion of the certificate program is approved by the instructors, the Industrial

Mathematics Program, and the Associate Dean of the College of Natural Science, the Office of the Registrar will enter the certificate on the student's academic record along with the term in which it was completed.

B. Master of Science Degree in Mathematics

The Master of Science Degree is only open to students in good standing in a PhD program at MSU. The degree requirements are as follows:

1. Pass with a grade of 3.0 or higher both semesters of two qualifying exam sequences.
2. Pass one qualifying exam (two semester content) at the Masters level.
3. Pass with a grade of 3.0 or higher twelve credits of any 800-900 level mathematics courses at MSU in addition to the twelve credits from (1).
4. Pass with a grade of 3.0 or higher six credits of graduate courses in a mathematically related field or of 400 level mathematics courses at MSU. These courses must be approved by the graduate director. No transfer credits will be allowed. Mathematics courses at the 800-900 level also satisfy this requirement.
5. A total of thirty credits is required, all with a grade of 3.0 or higher.

C. Master of Science Degree with Concentration in Applied Mathematics

This degree is awarded to masters students who as part of (1) above pass the numerical analysis sequence with a grade of 3.0 or higher in both semesters and as part of (3) above take at least six credits in 800-900 level Applied Mathematics courses (subject to the approval of the graduate director).

D. Residency Requirements and Time Limits for Master of Science Degrees

The time limit for completion of the requirements for all the Masters degrees is three (3) calendar years. The time starts with the start date of the first graduate course that the student is using to apply to the degree. For example, if a student is admitted in Fall Semester 2015 and wants to count a graduate course taken previous to that date toward the degree, the time starts with the earlier course.

IV. DOCTORAL DEGREES IN MATHEMATICS

The Department of Mathematics offers graduate work leading to the degrees Doctor of Philosophy and Doctor of Philosophy in Applied Mathematics. Admission to the doctoral program is limited to those applicants who possess a bachelor's degree in mathematics or equivalent preparation as determined by the Director of Graduate Studies. The requirements for the various doctoral degrees are listed below. Please note that credits used to satisfy requirements for a Master's degree may not be applied toward the requirements for a Ph.D. degree. Students must be enrolled the semester they take the qualifying and comprehensive examinations and the semester they defend their dissertation.

A. Ph.D. Degree in Mathematics

In order to receive the Ph.D. degree in mathematics the student must:

1. Satisfy the qualifying examination requirements.
2. Pass the comprehensive examination.
3. Take thirty credits of 800-900 level mathematics courses, excluding dissertation credits (Math 999) and core courses in areas in which the qualifying examination requirements are fulfilled. These courses must be approved by the student's guidance committee.
4. Satisfy the seminar requirement.
5. Take twenty-four credits of dissertation (Math 999).
6. Write and defend a doctoral dissertation acceptable to the student's dissertation committee.
7. Electronically submit the dissertation to the Graduate School and get final approval.

B. Ph.D. Degree in Applied Mathematics

The requirements are the same as for the Ph.D. in Mathematics with the following additions:

1. At least 18 credits of the 30 required in (3) above must be in approved applied mathematics courses and
2. The doctoral dissertation must be in an area of applied mathematics.

C. Dual Ph.D. Degree

The Mathematics Department offers the Dual Ph.D. degree jointly with other programs. University rules require that all dual major doctoral degrees must be approved by the Dean of the Graduate School. A request for the dual major degree must be submitted within one semester following its development and within the first two years of the student's enrollment at Michigan State University. A copy of the guidance committee report must be attached. The following conditions must prevail.

1. The intent to receive the degree in two areas must be outlined in the guidance committee report.
2. The content of the guidance committee report must reflect the required standards for both departments.
3. The integrated course work must be satisfactory to both departments.
4. The comprehensive examination must be passed to the satisfaction of both departments.
5. A guidance committee including members from both departments must be satisfied that the dissertation represents a contribution meeting the usual standards in both areas.
6. There must be a single dissertation that represents an integration of the disciplinary areas.
7. Responsible Conduct of Research requirements will be as defined and approved by the guidance committee.

The mathematics department distinguishes two type of candidates for the dual PhD program. The first type, primary candidates, are students who were originally admitted to the PhD program in mathematics. The second type, secondary candidates, are students who were originally admitted to the PhD program in another department or program. The distinction concerns the mathematics department's requirements for the dual degree.

Primary candidates must fulfill the qualifying course and exams requirements exactly as specified for PhD candidates in mathematics and in the same time frame. To fulfill the qualifying exam requirements in mathematics, secondary candidates must pass TWO qualifying exams within the first three years of the student's enrollment at Michigan State University.

For all candidates the comprehensive exam should be fulfilled as specified for PhD candidates in mathematics with two possible exceptions: (1) The exam can be taken any time after the qualifying exam requirements have been meet and before the end of the fourth year of the student's enrollment at Michigan State University. (2) The syllabus and questions prepared for the comprehensive exam by the student's guidance committee can include topics and questions from the dual program to allow the comprehensive exam to satisfy the requirements of the dual program. At least half the topics and questions should be in mathematics. The topics covered by the comprehensive exam must be approved by the graduate director and graduate studies committee.

For primary candidates the guidance committee and dissertation committee should consist of four or more tenure stream faculty members at least half of whom have a 50% or more appointment in mathematics. For secondary candidates the guidance committee and dissertation committee should consist of four or more tenure stream faculty members at least 40% of whom

have a 50% or more appointment in mathematics. The guidance committee must report to the graduate director the student's intent to do a dual degree and outline the topic or topics that could fulfill the university requirement that there be a single dissertation that represents an integration of the disciplinary areas. The report must, in addition, describe the program of study the student will follow to fulfill the requirements of both departments. This report is due before the end of the second year of the student's enrollment at Michigan State University. The report must be approved by the graduate director and the graduate studies committee before it is sent to the Dean of the Graduate School. After the student passes the comprehensive exam, the guidance committee is replaced by the dissertation committee. The duties of the dissertation committee are the same as the duties of the dissertation committee of a mathematics PhD dissertation committee (see below).

Primary candidates must take 21 credits of 800-900 level mathematics courses, excluding dissertation credits (Math 999) and qualifying exam course sequences. These courses must be approved by the student's guidance committee.

Secondary candidates must take 15 credits of 800-900 level mathematics courses, excluding dissertation credits (Math 999) and qualifying exam course sequences. These courses must be approved by the student's guidance committee.

D. Residency Requirements and Time Limits for all Ph.D. Degrees

One year of residence on the campus after completion of the master's degree or its equivalent is required to permit the student to work with the faculty, and to engage in independent and cooperative research utilizing University facilities. A year of residence will be made up of two consecutive semesters, involving the completion of credits at the level of full-time status of graduate work each semester.

Doctoral students must complete all comprehensive examinations with five years and all remaining requirements for the degree within eight years from the time the student takes the first class at MSU that appears on the student's doctoral program of study.

E. Credit-No Credit System

The University has a credit-no credit grading option but graduate degree candidates in the Department of Mathematics may not take any courses to be applied towards their degrees under the CR-NC system.

F. Qualifying Examination Requirements

Written qualifying examinations are given in five areas: (1) Algebra, (2) Partial Differential Equations, (3) Geometry/Topology, (4) Numerical Analysis, and (5) Real and Complex Analysis. These exams are based on syllabi available to the student. Ph.D. students in mathematics and applied mathematics satisfy the qualifying examination requirements by passing written examinations in three of the five areas.

Parallel to these exams the department offers five "core" sequences: (1) Algebra - MTH 818-819, (2) Partial Differential Equations - MTH 890-849, (3) Geometry/Topology - MTH 868-869, (4) Numerical Analysis - MTH 850, 852, and (5) Real and Complex Analysis - MTH 828-829. See the descriptions for these courses on pages 20-23 of this handbook. While these courses will cover much of the material on the corresponding exam syllabi, the student may need to learn some of this material, independently.

The qualifying exams will be given on the following schedule. In early January the Fall portion of the qualifying exams will be given. In early May the Spring portion of the qualifying exams will be given and together with the Fall portion, graded by a committee consisting of all available qualifying exam course instructors and the graduate studies committee. If a student fails one or more of the five exams the student may repeat the failed exams in August. The August exams will be given with both Fall and Spring portions together. The August exams will be graded by the same committee as the May exams. If the student has passed three exams the qualifying exam requirement is fulfilled. If the student has passed two exams the student may petition the graduate director to retake the failed exam in an oral exam format before the end of October. Passing the oral exam then fulfills the qualifying exam requirement. If the student has passed fewer than two exams after the August exam period or fails to pass the oral exam then the student has failed the qualifying exam requirement and must leave the PhD program. With permission of the graduate director, transfer into the Masters program is available for students who have failed to fulfil the qualifying exam requirement.

Incoming graduate students may attempt one or more of the August qualifying exams with permission of the graduate director. The graduate director will insure that incoming students have a reasonable chance at passing a qualifying exam before giving permission to attempt any exam.

G. The Comprehensive Examination

The content of the comprehensive exam will be decided by the student's guidance committee and will cover material germane to the student's research interest. The guidance committee, with the student, will prepare the syllabus at least three months before the exam. The comprehensive exam will consist of two components. The first part will be a two to three hour written exam. The

written exam questions will be prepared by the student's guidance committee. The second part will be a one-hour oral exam. In both parts the questions will be based upon the written syllabus. There should only be a short break between the written and oral components to maintain the integrity of the exam. Following the exam, the written questions will be available to interested students and faculty. The written exam will be kept by the graduate office for three years following completion of the exam.

The exam may be taken twice. The initial attempt of this exam must be before the end of fall semester of third year. The second attempt, if necessary, before the end of spring semester of third year. Failure to pass the comprehensive exam after the second attempt will result in loss of good standing and termination from the program.

The purpose of the exam is to determine mastery of an area of mathematics. The content of the exam should be roughly that of a one semester course (or perhaps a two semester sequence of courses) at the 900 level. It should be material known to most researchers in the field. The guidance committee may examine the student on more specialized topics, at its discretion. The student should be able to learn the material in two semesters from completion of the qualifying exams. In fact, the content of the exam may overlap with that of graduate courses.

If one of the committee members is not available to attend the exam, the student can still be tested and either pass or fail by majority vote.

H. Dissertation Advisor

It is the responsibility of the student to obtain a dissertation advisor before the end of the third year in the PhD program. Failure to obtain an advisor will result in loss of good standing and termination from the program. If the student finds a dissertation advisor before passing the comprehensive exam the dissertation advisor should become chair or co-chair of the guidance committee. If the student finds a dissertation advisor after passing the comprehensive exam the dissertation advisor must become the chair or co-chair of the dissertation committee.

I. Ph.D. Seminar Requirement

Each Ph.D. student must give at least two fifty-minute seminar talks. The talks, which should be at an advanced level, can be given either in a faculty or student seminar. The completion of this requirement must be certified by a faculty member knowledgeable in the area covered by the talks. A student should be certified as having fulfilled this requirement only if the talks are reasonably good, both in content and form.

J. Guidance Committee and Dissertation Committee

The guidance committee shall be formed no later than the third semester of doctoral study. This committee, a Graduate School requirement, shall consist of four members. It is the student's responsibility to form the committee with the approval of the graduate office. The guidance committee must be chaired or co-chaired by a regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics. Furthermore, at least two of the four guidance committee members must be regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics. The student should seek faculty reflecting their research interests though this is not required. The committee can be changed with approval of the graduate office.

The Graduate School allows guidance committees with more than four members. If this occurs at least half of the members of the committee must be regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics.

The responsibilities of the guidance committee are:

1. To plan the student's program, taking into account the student's goals and the courses and seminars appropriate to these goals.
2. To assess progress, approve program changes, and to offer its best advice.
3. To prepare a syllabus for the comprehensive examination.
4. To indicate a timetable for the completion of courses and the comprehensive examination.
5. To prepare the written portion of the comprehensive exam.
6. To administer the comprehensive exam and to determine pass/fail.

It is the responsibility of the student to plan a tentative program and have it approved by his or her guidance committee. This will be done by completing the online form in GradPlan. The GradPlan form/process requires doctoral students to fill out a preliminary program plan to be checked by the Graduate Coordinator. The form will then be sent electronically to committee members for approval. All of the student's pertinent academic information will be stored in GradPlan (date of comprehensive exams, completion of RCR program, title of dissertation, etc.).

After the student passes the comprehensive examination and the student has obtained a dissertation advisor, the guidance committee for that student will be restructured into the dissertation committee chaired or co-chaired by the dissertation advisor. The dissertation

committee is to consist of four members, selected by the student and the dissertation advisor with approval of the Graduate Director. These members must agree to be on the committee. The dissertation committee must be chaired or co-chaired by a regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics. Furthermore, at least two out of four dissertation committee members must be regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics.

The Graduate School allows dissertation committees with more than four members. If this occurs at least half of the members of the committee must be regular tenure system faculty member currently having at least a 50% appointment in the Department of Mathematics.

The responsibilities of the dissertation committee include:

1. Assessing the student's progress.
2. Planning the seminar and research phase of the student's work, not excluding additional course requirements in areas deemed appropriate to the student's research.
3. Reading and approving the dissertation.

If, for any reason, a student desires to change a member of the guidance or dissertation committee, including the guidance committee chairperson or dissertation advisor, the change should be requested as early as possible. Any changes should be discussed with the graduate director, the current member, and the prospective new committee member, prior to initiation.

K. The Dissertation

Every doctoral candidate must write a dissertation acceptable to the faculty. The dissertation is to be an original and significant contribution to mathematical knowledge. It constitutes evidence that the candidate is a well-trained and capable research worker in some specialized area of mathematics. The research on the dissertation is done under the guidance of the dissertation advisor and dissertation committee.

L. The Dissertation Defense

The final public oral examination in defense of the dissertation is conducted by the dissertation committee and is arranged by the candidate in consultation with the dissertation committee and the Director of Graduate Studies. The candidate must present copies of the dissertation to the committee *at least three weeks* prior to the date of the defense. It is the responsibility of the candidate to determine that all members of the committee are available on the expected date of the defense. Requests for changes or

substitutions in the dissertation committee must be submitted to and approved by the Director of Graduate Studies at least four weeks prior to the anticipated date of the defense. Last minute requests for changes may not be honored.

M. Electronic Submission of Ph.D. Dissertations

After passing the dissertation defense, candidates must electronically submit their dissertation to the Graduate School via ProQuest. The instructions for electronic submission are available from http://grad.msu.edu/etd/.

The target date for final approval of an electronically submitted dissertation, to insure that the student will graduate in the semester the dissertation was submitted, is five (5) working days prior to the first day of classes for the next semester (see future target dates below). Be aware that a submission via ProQuest does not mean that the document has been accepted. The review process is interactive and final approval can take anywhere from a few hours to weeks, depending upon the extent of the necessary revisions and how quickly they are completed.

Graduation in the semester of the electronic submission is only guaranteed if the document is approved on or before the target date for that semester.

V. GRADUATE COURSES (These courses will be revised/changed in Fall 2015)

A. 800 Level Courses

810 **Error-Correcting Codes** Spring
Prerequisite: Math 411 or MTH 414 or MTH 415
Block codes, maximum likelihood decoding, Shannon's theorem. Generalized Reed-Solomon codes, modification of codes, subfield codes. Alternant and Goppa codes, cyclic codes and BCH codes.

818 **Algebra I** Fall
Prerequisite: MTH 411 or equivalent
Group theory: Sylow theory, permutation groups, Jordon-Holder theory, Abelian groups, free groups. Ring theory: algebra of ideals, unique factorization, polynomial rings, finitely generated modules over PID's.

819 **Algebra II** Spring
Prerequisite: MTH 818
Modules and vector spaces, projective modules, tensor algebra. Fields and Galois groups, algebraic and transcendental numbers, non-commutative rings. The Jacobson radical, the structure of semisimple rings with the descending chain condition.

828 **Real Analysis I** Fall
Prerequisites: MTH 421, MTH 461 or equivalent
Lebesgue measure on real line, general measure theory. Convergence theorems, Lusin's theorem, Egorov's theorem, L^p-spaces, Fubini's theorem. Functions of bounded variation, absolutely continuous functions, Lebesgue differentiation theorem.

829 **Complex Analysis I** Spring
Prerequisites: MTH 421, MTH 425 or equivalent
Cauchy theorem, identity principle, Liouville's theorem, maximum modulus theorem. Cauchy formula, residue theorem, Rouche's theorem. Casorati-Weierstrass theorem, Arzela-Ascoli theorem. Conformal mapping, Schwarz lemma, Riemann mapping theorem.

840 **Chaos and Dynamical Systems** Spring
Prerequisites: MTH 320 and MTH 414, some experience with mathematical software such as Mathematica or Matlab
Chaotic or random motions in differential and difference equations.

841 **Boundary Value Problems I** Fall
Prerequisites: MTH 414, MTH 421 or equivalent
Boundary value problems for ordinary and partial differential equations. Sturm-Liouville theory. Fourier series and generalized Fourier series. Eigenfunction expansions. Variational methods. Fredholm integral equations. Potential theory. Green's functions. Special functions. Integral transform methods.

842 **Boundary Value Problems II** Spring
Prerequisite: MTH 841
Continuation of MTH 841.

843 **A Survey of Industrial Mathematics** Fall
Prerequisites: MTH 414, MTH 421, MTH 442, and Some familiarity with mathematical software such as Mathematica, Matlab, etc. Open only to masters students in the Industrial Mathematics major or approval of department.
Fundamentals of mathematical modeling in government and industry, including modes of industrial communication. The course has three objectives: to survey mathematics of particular importance to industry, to gain experience in team project report generation, and to gain experience in oral presentation of technical reports.

844 **Projects in Industrial Mathematics** Spring
Prerequisite: MTH 414, MTH 421, MTH 442, MTH 843, and Some familiarity with mathematical software such as Mathematica, Matlab, etc. or approval of department.
Representatives from Industry or Government will come to campus to pose problems of interest to their unit. Students will divide into teams to tackle one of the posed problems. By the end of term each student team will present both a written and oral report of their findings to the industrial or governmental unit that posed the problem. Teams will be advised by a faculty member plus a liaison from the unit that posed the problem.

847 **Partial Differential Equations I** Fall
Prerequisites: MTH 414, MTH 421 or equivalent
Cauchy-Kowalewski theorem. Characteristics. Initial-boundary value problems for parabolic and hyperbolic equations. Energy methods, boundary value problems for elliptic equations, potential theory. Green's function, maximum principles, Schauder's method.

849 **Partial Differential Equations** II Spring
Prerequisites: MTH 414, MTH 421 or equivalent
Continuation of Math 847

850 **Numerical Analysis I** Fall
Prerequisites: MTH 414, MTH 421 or equivalent
Convergence and error analysis of numerical methods in applied mathematics.

852 **Numerical Methods for Ordinary Differential Equations** Spring
Prerequisite: MTH 850
Linear multi-step methods and single step nonlinear methods for initial value problems. Consistency, stability and convergence. Finite difference, finite element, shooting methods for boundary value problems.

868 **Geometry and Topology I** Fall
Prerequisite: MTH 411, MTH 421 or equivalent
Fundamental group and covering spaces, vanKampen's theorem. Homology theory, differentiable manifolds, vector bundles, transversality, calculus on manifolds. Differential forms, tensor bundles, deRham theorem, Forbenius theorem.

869 **Geometry and Topology II** Spring
Prerequisite: MTH 868
Continuation of MTH 868.

880 **Combinatorics** Fall
Prerequisite: MTH 411 or MTH 482 or equivalent
Enumerative combinatorics, recurrence relations, generating functions, asymptotics, applications to graphs, partially ordered sets, generalized Möebius inversions, combinatorial algorithms.

881 **Graph Theory** Spring
Prerequisite: MTH 880
Graph theory, connectivity, algebraic and topological methods. Networks, graph algorithms, Hamiltonian and Eulerian graphs, extremal graph theory, random graphs.

890 **Reading in Mathematics** Every Semester
Prerequisite: Approval of department
Individualized study for master's level students.

B. 900 Level Courses

910 **Commutative Algebra** Fall of odd years

912 **Group Theory I** Fall of even years
Prerequisite: MTH 819
Permutation groups, solvable and nilpotent groups, simple groups. Representation and character theory. Extension theory and cohomology groups.

913 **Group Theory II** Spring of odd years
Prerequisite: MTH 912
Groups of Lie type, linear groups, locally finite groups, free groups and free products, the subgroup theorems.

914 **Lie Algebras** Fall of odd years

916 **Algebraic Geometry I** Fall of odd years
Prerequisites: MTH 818 and MTH 819
Affine and projective algebraic varieties and their properties. Morphisms and singularities. Schemes and coherent sheaves. Sheaf cohomology and other related topics.

917 **Algebraic Geometry II** Spring of even years
Prerequisite: MTH 916
Continuation of MTH 916.

918 **Number Theory I** Fall of even years

919 **Number Theory II** Spring of odd years

920 **Functional Analysis I** Fall
Prerequisite: MTH 828
Introduction to Hilbert spaces, Banach spaces and locally convex vector spaces. Topics include Riesz representation theorem, Parseval's identity, Riesz-Fisher theorem, Fourier series operators, Hahn-Banach theorem, open

mapping and closed graph theorems, Banach-Steinhaus theorem, duality theory for locally convex spaces, convexity, Krein-Milman theorem, theory of distributions, compact operators.

921 **Operator Theory** Spring of odd years
Prerequisites: MTH 829 and MTH 920
Introduction to operator and spectral theory. Topics include Banach algebras, bounded and unbounded operators on Banach spaces, spectral theory for normal operators on a Hilbert space, C*-algebras, Schatten - von Neumann classes, the theory of Fredholm operators, semigroup theory.

922 **Harmonic Analysis** Fall of odd years
Prerequisites: MTH 829 and MTH 920
Introduction to Fourier analysis and singular integral operators. Topics include mean and pointwise convergence of Fourier series, Fourier transform, Plancherel theorem, Paley-Wiener theorem, interpolation of operators, maximal functions and Calderon-Zygmund theory of singular integral operators.

925 **Random Variables and Stochastic Processes** Fall
Prerequisites: MTH 829
Introduction to measure theoretic probability theory. Topics include infinite product spaces, Kolomogorov extension theorem, Borel Cantelli Lemma, law of large numbers, central limit theorem, conditioning, filtrations, martingales, Markov chains, Wiener process.

928 **Real Analysis II** Spring of odd years
Prerequisites: MTH 828
Continuation of MTH 929. Topics include Borel measures on locally compact spaces, complex measures, differentiable transformations and changes of variables in Rn.

929 **Complex Analysis II** Spring of even years
Prerequisites: MTH 828, MTH 829
Continuation of MTH 829. Topics include Phragmen-Lindelof method, Analytic continuation and Riemann surfaces, Hadamard's theorem, Runge's theorem, Weierstrass factorization theorem, Mittag-Leffler theorem, Picard's theorem, Hp-spaces, Blaschke products.

930 **Riemannian Geometry I** Fall
Prerequisite: MTH 869
Riemannian metrics, connections, curvature, geodesics. First and second variation, Jacobi fields, conjugate points. Rauch comparison theorems, Hodge theorem, Bochner technique, spinors. Further topics on curvature or submanifold theory.

931 **Riemannian Geometry II** Spring of odd years
Prerequisite: MTH 930
Continuation of MTH 930.

935 Complex Manifolds Spring of even years
Prerequisites: MTH 829, MTH 869
Riemann surfaces, Serre duality, Riemann-Roch theorem. Weierstrass points, Abel's theorem, Plucker formulas. Hermitian metrics, connections, curvature, Hodge theorem. Kaehler metrics, Kodaira vanishing theorem, Chern classes.

940 Topics in PDE for Applied Math Fall of odd years
Prerequisite: MTH 847, MTH 849
PDE techniques that frequently appear in applied math. Including bifurcation theory, PDE as dynamical systems, boundary layers, asymptotic analysis, matched asymptotics / singular perturbations, and some homogenization examples.

941 Linear and Nonlinear Parabolic Equations Spring of even years
Prerequisite: MTH 847, MTH 849
Evolution equations that have a comparison principle-- e.g. parabolic and Hamilton-Jacobi-Bellman equations. Both linear and nonlinear examples, including some quasi-linear equations related to geometric flows. Existence and uniqueness of both classical solutions and weak solutions— so-called viscosity solutions.

942 Regularity for Second Order Elliptic Equations Fall of even years
Prerequisite: MTH 847, MTH 849
Review of some classical results, such as Schauder and L-p theory, subsequently moving onto equations with coefficients of low regularity (i.e. only bounded and measurable) and nonlinear elliptic equations. The Harnack inequality and Holder regularity will be established in the context of both weak solutions of divergence form equations and viscosity solutions for equations in nondivergence form via respectively the methods of De Giorgi and Krylov-Safonov. Higher regularity and applications to minimization problems.

943 Hyperbolic and Dispersive Equations Spring of odd years
Prerequisite: MTH 847, MTH 849
Classical and modern techniques for higher dimensional hyperbolic and dispersive PDE, whose solutions spread out and decay due to wave packets traveling at different velocities. Space-time integral estimates, including the classical Strichartz estimate for Schrodinger, Klein-Gordon, and Wave equations. More modern (multi)linear estimates using a variety of Fourier, physical-space, and microlocal techniques.

950 Numerical Methods for Partial Differential Equations I Spring of odd years
Prerequisite: MTH 852
Finite difference methods for ordinary and partial differential equations.

951 Numerical Methods of Partial Differential Equations II Spring of even years
Prerequisite: MTH 950
Finite element methods for ordinary and partial differential equations.

960 Algebraic Topology I Fall
Prerequisite: MTH 869
Cohomology, products, duality, basic homotopy theory, bundles, obstruction theory, spectral sequences, characteristics classes, and other related topics.

961 **Algebraic Topology II** Spring
Prerequisite: MTH 960
Continuation of MTH 960

970 **Dynamics** Fall
Prerequisite: MTH 868
Flows and diffeomorphisms, Examples, Topological and Smooth Conjugacy, Recurrence and Limit Sets, Circle Diffeomorphisms, Symbolic Spaces and Expanding Maps, Structural Stability of Expanding Maps, Perron-Frobenius Theorem and Discrete Markov Processes, Topological Entropy and Volume Growth, Zeta Function, Homological Growth, Linearization, Bifurcation Theory.

988 **Representation Theory I** Fall of odd years

989 **Representation Theory II** Spring of even years

990 **Reading in Mathematics** Every Semester
Prerequisite: Approval of department
Individualized study for doctoral level students.

991 **Special Topics in Algebra** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in algebra.

992 **Special Topics in Analysis** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in analysis.

993 **Special Topics in Geometry** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in geometry.

994 **Special Topics in Applied Mathematics** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in applied mathematics.

995 **Special Topics in Numerical Analysis and Operations Research** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in numerical analysis or operations research.

996 **Special Topics in Topology** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in topology.

997 **Special Topics in Dynamics** Fall, Spring
Prerequisite: Approval of department.
Advanced topics in dynamics.

998 **Special Topics in Combinatorics and Graph Theory** Fall, Spring

Prerequisite: Approval of department.
Advanced topics in combinatorics and graph theory.

999 **Doctoral Dissertation Research** Every Semester
Prerequisite: Approval of department.
Doctoral dissertation research.

VI. GRADUATE TEACHING ASSISTANTSHIPS

A. General Information

The University criteria for awarding, renewing, and terminating graduate teaching assistants can be found in the MSU/GEU contract: http://www.hr.msu.edu/documents/contracts/GEU2011-2015.pdf.
The policies stated below are subservient to new contract agreements that may be posted in the above website in the future.

The Department of Mathematics employs many graduate students in mathematics as teaching assistants each fall and spring semester. An assistant's duties include teaching courses, assisting in recitation sections and serving as a tutor in the MLC (Mathematics Learning Center). The Department estimates that teaching combined with lecture preparation, paper grading, student consultations and sessions in the MLC takes about twenty hours per week. Teaching assistants are granted a nine credit per semester tuition waiver for fall and spring semesters and a five-credit tuition waive for summer semester. In addition, registration fees are waived and assistants are automatically enrolled in a health insurance plan, the premium of which is paid by the University.

B. Graduate Student Instructor Policy:

The Department of Mathematics places a very high value on the delivery of excellent mathematics instruction to all students enrolled in the classes we administer. It is essential that graduate students supported by the Department be fully and professionally engaged in their teaching assignment, whether it is lecture, recitation, or time in the Mathematics Learning Center (MLC). In particular, these assignments are binding and non-transferable, they must be fulfilled, and fulfilled by the designated instructor. Absences of more than one day of consecutive teaching duties, or more than two days cumulatively during a given semester, must be approved in advance in writing by the Graduate Director, or must be excusable retroactively for medical or other emergency justification.

C. Mandatory Training

All TAs and RAs must complete the on-line training about the Relationship Violence and Sexual Misconduct Policy. To Access the training, login to the ORA training website at: https://train.ora.msu.edu/Saba/Web/Main/goto/CertificationDetailDeeplinkURL?certificationId=crtfy000000000001180&baseType=0&pageMode=GuestLogin. Click "Register," "Complete Registration" and then "Launch" to begin the Relationship Violence and Sexual Misconduct (RVSM) Policy - Faculty, Staff Training. (If it indicates that you have already registered, use "In Progress Training", then "Launch."). You will want to reserve approximately 30 minutes to complete all assignments. If you need assistance, contact the Helpdesk at 517-884-4600 or train@ora.msu.edu.

D. Departmental Orientation

All new graduate teaching assistants are required to attend an orientation program prior to teaching courses or recitations. The purpose of this program is to acquaint the graduate assistants with the policies and procedures of the University and the Department of Mathematics and to provide a valuable tools to enable the graduate assistants to become successful teachers.

E. Vehicle Registration

If you own a motor vehicle or a bicycle and want to use it on campus, you must register it with the University Vehicle Office. The Vehicle Office is located in the Public Safety Building, 87 S. Red Cedar Road. To register a vehicle you need your student ID, current vehicle registration, proof of insurance, and a copy of your appointment form which is given to you by the Graduate Coordinator.

F. Health Insurance

"Student only" coverage will be automatically provided, at no cost to graduate assistants. Michigan State University will provide a full twelve months of coverage if your appointment is at least nine months. No enrollment is necessary, unless you wish to enroll your legal spouse and/or dependent children.

G. Language Skills

New graduate assistants for whom English is not a primary language are required to take and pass the SPEAK Test before they can be assigned teaching duties. Michigan State University requires a minimum score of 50 or waiver approval prior to being allowed to teach. Students who do not pass the SPEAK Test will be given an assignment of 12 sessions per week in the MLC. The expectation is that they will be able to improve their language skills and assume classroom duties in later semesters. Lack of progress in language skills as evidenced by the inability to successfully pass the SPEAK Test and undertake a classroom assignment may lead to loss of the assistantship after the first year.

H. Reappointments

At the beginning of spring semester you will be asked to indicate whether or not you wish to be reappointed as a graduate assistant for the following academic year. Requests for reappointment are considered by the graduate studies committee and decisions are made in April. Graduate assistants in the doctoral program will not be reappointment beyond the sixth year. Unsatisfactory performance of teaching duties or violation of general student regulations contained in the Student Rights and Responsibilities document**,** can result in termination of an assistantship, following the procedures specified in the MSU/GEU contract. Teaching performance is evaluated at the end of each semester by

course supervisors, and evaluations are kept in the students' assistantship file according to the MSU/GEU contract.

I. Summer Support

The budget for teaching in the summer semester is very limited. The department can usually support about sixty students as teaching or research assistants. The teaching and research assistantships for summer are awarded on a merit basis. If sufficient enrollment information is available, students will receive a reappointment letter in March. If sufficient enrollment information is not available, students will receive a letter informing them that they have not been reappointed for summer but that their names have been placed in a pool of qualified applicants. They will be offered an assistantship when sufficient enrollment information is available.

J. Course Loads

1. Master's students with assistantships are required to enroll in a minimum of 6 credits in both fall and spring semesters and three credits in summer semester. If the student does not have an assistantship in the summer no credits are required.

2. Master's students without assistantships are required to enroll in a minimum of 9 credits in both fall and spring semesters. No credits are required in the summer.

3. Doctoral students with assistantships are required to enroll in a minimum of 3 credits in all semesters. If the student does not have an assistantship in the summer no credits are required.

4. Doctoral students without assistantships are required to enroll in a minimum of 6 credits in both fall and spring semesters. If the student does not have an assistantship in the summer no credits are required.

5. Doctoral students who have passed the comprehensive exam are only required to enroll in 1 credit in each semester subsequent to the semester in which the comprehensive exam is passed. This holds provided the "Record of Comprehensive Examinations" form, with all appropriate signatures, has been sent to the Dean's office no later than thirty days prior to the beginning of the semester in which the one credit full-time status will be effective.

6. Doctoral students who were full time in fall and spring semesters can enroll for only 1 credit in the summer.

7. The maximum course load for a half-time assistant is twelve credits per semester unless written permission to carry more is obtained from the dean's office prior to registration.

VII. 999 CREDITS

1. Doctoral students who have passed all qualifying exams can register for Math 999 (research credits). 24 credits are required for graduation; students can enroll for a maximum of 36. Students should start to accumulative these credits as soon as possible.

2. Requests for overrides to exceed the maximum of 36 credits of 999 must be directed to the Office of the Registrar. To do so, access the ***"Request for RNR Override" at the Registrar's Online Forms Menu at https://www.reg.msu.edu/Forms/FormsMenu.aspx. Select the RN override and fill in the requested information.*** Should the total number of credits go above 45 the RO will confer with the Graduate School before considering the request for an override.