DEPARTMENT OF MATHEMATICS AND STATISTICS

GRADUATE STUDENT HANDBOOK

February 2016

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1 Introduction

This handbook offers guidance to students working toward advanced degrees in mathematics and statistics at Washington State University. These degrees are MS in Mathematics (which also has an Applied Mathematics Option and a Mathematics Teaching Option), MS in Statistics (and a Graduate Minor in Statistics), PhD in Mathematics (which also has an Applied Mathematics Option and an option that allows obtaining an MS in another discipline simultaneously), and PhD in Mathematics with Education Emphasis.

In all of our degree programs we attempt to combine a sound general core of fundamental mathematics and statistics with electives that reflect individual interests, needs, and opportunities. People having one of these degrees will be better at some things than at others, but they will have a general grounding in mathematics and statistics that should be valuable to them in any mathematical or statistical work they do.

Graduate students should accept much of the responsibility for their own training. This includes not only planning a meaningful program of study, studying for courses and examinations, and writing a thesis, but also voluntarily and energetically devoting time to outside reading of both books and journals; attending colloquia and special lectures by local and visiting speakers; working on assigned problems; participating actively in credit and noncredit seminars and professional meetings; and frequently discussing mathematics or statistics with colleagues. Active mathematicians and statisticians do these things as a matter of course, and graduate school is not too soon to develop these habits.

In reading this document, one should bear in mind that some of the regulations and requirements contained herein come from the Graduate School and are university-wide in scope, while others originate in the Department of Mathematics and Statistics and pertain only to mathematics and statistics students. Among the former are rules pertaining to the Master's and Doctoral Final Oral Examinations, the Doctoral Preliminary Examination, total hours required for each degree, and format of thesis or dissertation. On the other hand, specific course requirements and rules governing the Graduate Qualifying Examination and the Doctoral Qualifying Examination are of departmental origin.

There are many more resources and important information available at the Graduate School website. In particular, make sure that you consult the page about New and Current Students. and the current issue of the Graduate School Policies and Procedures Manual. This manual is the definitive source for information on Graduate School regulations and requirements, and as such statements in it take precedence over those in this guide as far as the Graduate School regulations and requirements are concerned. This guide is the official source of information concerning departmental regulations and requirements valid on the date of issue.

Departmental policies pertaining to graduate programs are set by the graduate faculty of the Department of Mathematics and Statistics. The departmental Graduate Studies Committee serves as an intermediary between the graduate students and the graduate faculty. Questions concerning the content of this document, and petitions requesting possible waiver or modification of any rule of departmental origin should be directed to this committee. Students should feel free to seek advice or assistance from any member of the mathematics faculty, and especially from the Chair of the Department, the Associate Chair of the Department, and the members of the Graduate Studies Committee. In addition, students should feel free to seek assistance from the Graduate Program Coordinator on administrative matters pertinent to the graduate programs of the Department.

As will be clear from the remaining sections of this handbook, there is a substantial amount of flexibility in graduate study in mathematics and statistics at Washington State University. For students interested in more applied areas, it might be mentioned that for a number of years the department has placed considerable emphasis on the development of educational options leading to possible careers in business, industry, and government. Current options include computational mathematics, mathematical modeling, operations research and mathematics education. These options may be incorporated into programs of study leading to either an MS or a PhD degree (or both).

For an up-to-date list and description of Mathematics and Statistics courses offered, consult the University Catalog.

2 Summary of Procedures for MS Degrees

Procedure	Under the Direction of	Date
Obtaining an advisor	Chair of Graduate Studies Committee	As soon as possible after admission to Graduate School
Training on Responsible Conduct of Research Education	Graduate School See §15.1	As soon as possible after admission to Graduate School
Submission of Program of Study	Department Chair, Advisor, Master's Committee	See Navigating Your Degree
Application for degree[a]	Graduate School	See Navigating Your Degree
Scheduling of Final Examination[b]	Graduate School	See Navigating Your Degree
Final Examination	Master's Committee, Graduate Faculty, Department Chair, Graduate School	See Navigating Your Degree

NOTE:

[a] It is strongly advised that the application for a degree be submitted **one semester before the final examination** is scheduled so that students can be notified of graduation requirements (to-do lists) before enrolling for their last semester.

[b] Submit completed scheduling form (including approved examination date, hour and place) to the Graduate School Office **at least 10 working days prior to the examination date.**

All forms may be picked up in the Graduate School Office, or downloaded via the web.

All program changes should be submitted on program change forms. Committee changes should be submitted to the Graduate School on forms provided and signed by the Chair of the major department and the Chair of the committee.

ENROLLMENT:

Students are responsible for satisfying all enrollment requirements stated in the Graduate School Policies and Procedures Manual and in §15 of this handbook.

3 The MS in Mathematics

3.1 Description and Learning Outcomes

The degree of Master of Science (MS) in Mathematics represents substantial mathematical training beyond the baccalaureate, which is sufficient for many career goals. Doctoral students complete most of the MS requirements in the course of their studies, and often receive an MS degree as an intermediate step en route to the doctorate. However, the MS degree is efficacious in its own right, and is not necessarily a stepping stone to a doctoral degree. Furthermore, attainment of the MS degree does not guarantee admission to a doctoral program.

This MS program is designed to lead the student to the following learning outcomes:

1. Problem Solving: Students will be able to identify mathematical and computational methods in order to solve problems.
2. Deductive Thinking: Students will be able to read and write logical arguments in order to prove advanced mathematical results.
3. Effective Communication: Students will be able to effectively communicate mathematical concepts, problems and their solutions in written and oral form.

Departmental requirements and regulations for the MS degree are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

3.2 Prerequisites

All graduate students are expected to have a background in mathematics equivalent to that provided by our undergraduate degree. Ideally, this would include familiarity with the material covered in Math 401 and 402, and Math 420 and 421, and some experience with computer programming. Students with a deficient background are expected to make up these deficiencies at the earliest opportunity.

3.3 Courses and Hours

A candidate must complete 31 semester hours of approved graduate work, including Math 501. These courses must be numbered 400 or above (except for up to 3 hours of 300 level courses in other areas) and must include 26 hours of graded course work. At least 18 of these hours must be in mathematics courses numbered between 501 and 574, or Math 586, or statistics courses numbered 519, 533, 544, 548, 549, 573. At least four hours of Math 702 and one hour of Math 500 are required.

3.4 Transfer Credit

Up to eight hours of transfer credit may be given for suitable course work done elsewhere. Transfer credit is requested by listing the courses on the Program of Study (see §3.5); approval of the Program of Study implies approval of transfer of credit. Other general regulations regarding Transfer Credit can be found in Chapter 6 of the Graduate School Policies and Procedures Manual.

3.5 The Program of Study

A Program of Study must be submitted by the deadlines indicated in §2. It is however suggested that this be done in the second semester of graduate work. The appropriate form is available at the Graduate School Office or may be downloaded from its web site.

3.6 The MS Examination

Each master's student must pass a final oral examination, which will cover all of the student's course work including Math 702 (see §3.8 below) plus the content of Math 401, 402, 420 and 421. This examination may be scheduled when all requirements of the Department and the Graduate School have been satisfied (or are expected to be satisfied by the end of the current semester). The deadlines for scheduling this examination are indicated in §2. The student's advisory committee will conduct this examination.

3.7 The Application for Degree

An Application for Degree must be filed with the Graduate School by the deadlines in §2. An approved Program of Study must be on file in the Graduate School before the Application for Degree may be filed. Candidates may not schedule a final examination until an Application for Degree has been filed.

3.8 Thesis

There is no thesis requirement. However, a master's student must take four hours of Math 702. This involves independent study under the guidance of a faculty member, normally the chair of the student's advisory committee. The results of this study are often summarized in a paper, but this is not mandatory.

4 The MS in Mathematics (Applied Mathematics Option)

4.1 Description and Learning Outcomes

This is a two-year professional degree especially designed to train mathematicians and scientists/engineers with strong mathematics backgrounds in up-to-date applied mathematical, computational and statistical skills. Such training is intended to produce high caliber individuals who can confidently undertake interdisciplinary research. The focus will be in preparing talented individuals to face the mathematical and other research challenges in business and/or industrial sectors. In order to achieve these goals the program requires:

- a broad background in the areas of Numerical Analysis/Optimization, Modeling/Simulation, and Statistical Analysis;
- a concentration in one of the above areas;
- both group and individual projects;
- a strong computing component.

The learning outcomes in §3.1 also apply.

Departmental requirements and regulations for the MS in Applied Mathematics are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

4.2 Prerequisites

Same as in §3.2.

4.3 Courses and Hours

A candidate must complete at least 35 semester hours of course work. This includes:

(a) a core consisting of:

Math 540 and 548;
Math 464 and either 566 or 564;
Math 516;
Math 443 and either Stat 523 or 572;
and Math 500; and

(b) at least three additional graduate level mathematics courses including at least two from one of the following groups (*Note:* these three courses should not have been used to satisfy the above core requirements):

Numerical Analysis/Optimization	**Modeling/Simulation**	**Statistical Analysis**
Math 544, 545, 546, 564, 565, 566, 567, 574	Math 415, 570, 571, 579, 586; Stat 536	Stat 523, 544, 572, 573

4.4 Transfer Credit

Same as in §3.4.

4.5 The Program of Study

Same as in §3.5.

4.6 The MS Examination

Each MS in Applied Mathematics student must pass a final oral examination that covers all of the student's course work plus the content of Math 401, 402, 420 and 421, and includes an oral presentation on the results of the student's Math 702 individual project (see §4.8 below). This examination may be scheduled when all requirements of the Department and the Graduate School have been satisfied (or are expected to be satisfied by the end of the current semester). The deadlines for scheduling this examination are indicated in §2. The student's advisory committee will conduct this examination.

4.7 The Application for Degree

Same as in §3.7.

4.8 Thesis

There is no thesis requirement. However, a student must take four hours of Math 702. Two of the Math 702 credits must involve the completion of a group project and two of the Math 702 credits must involve the completion of an individual project.

The group projects should normally be completed by the end of the third semester of the student's work on the degree. A team of at least two faculty members, drawn from different areas of applied mathematics or other application areas, will supervise these projects. Each project group must submit a group project report by the end of the project semester, and each group must provide an oral presentation to the project committee, summarizing the results of the project.

The individual project should normally be completed by the end of the fourth semester of the student's work on the degree. The student's advisory committee members will supervise this project. A written project report should be submitted when the project is completed. The final MS examination must include an oral presentation by the student about the results of the project, with questions from the student's MS committee.

4.9 The Electives and Internship

During a standard two-year program, a student taking 10 credit hours (most students take more) will have time to include several elective courses in addition to the course work required in §§5.3,4.8. Students are strongly encouraged to spend a summer on an internship and to attend seminars in applied mathematics. These elective courses, internship, and the individual project (see §4.8) should be unified to form an effective combination in a particular specialty of interest to each student.

5 The MS in Mathematics (Computational Finance Option)

5.1 Description and Learning Outcomes

This is a Master of Science degree especially designed to train students with strong mathematics backgrounds in up-to-date mathematical and computational skills in quantitative finance and insurance. Such training is intended to produce high caliber individuals who can confidently undertake interdisciplinary research and analysis in modern financial risk management. The focus will be in preparing talented individuals to face the quantitative and computational challenges in financial service and insurance sectors. In order to achieve its goals this program requires:

- a solid training in Financial Mathematics, Optimization, Stochastic Simulation;
- a broad background in the areas of Finance and Insurance, Numerical Analysis, and Statistical Analysis;
- both group and individual projects;
- a strong computing component.

The learning outcomes in §3.1 also apply.

Departmental requirements and regulations for the MS in Computational Finance are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

5.2 Prerequisites

Same as in §3.2.

5.3 Courses and Hours

A candidate must complete at least 31 semester hours of course work. This includes:

(a) a core consisting of:

Math 464 or Math 564, Optimization;
Math 516 or Stat 536, Simulation;
Math 575, Asset Pricing in Financial Engineering;
Math 576, Quantitative Risk Management; and

(b) at least two additional graduate level courses from Group 1 and at least three additional graduate level courses from Group 2 below:

(1) Fin 521 (Interest Rates and Financial Markets), Fin 526 (Problem in Financial Management), Fin 527 (Investment Analysis), Fin 528 (Portfolio Management), Fin 581 (International Finance).

(2) Math 545 (Numerical Analysis of Evolution Equations), Math 548 (Numerical Analysis), Math 565 (Nonlinear Optimization), Stat 523 (Statistical Methods), Stat 516 (Time Series), Stat 519 (Applied Multivariate Analysis).

5.4 Transfer Credit

Same as in §3.4.

5.5 The Program of Study

Same as in §3.5.

5.6 The MS Examination

Each MS in Applied Mathematics student must pass a final oral examination that covers all of the student's course work plus the content of Math 401, 402, 420 and 421, and includes an oral presentation on the results of the student's Math 702 individual project (see §4.8 below). This examination may be scheduled when all requirements of the Department and the Graduate School have been satisfied (or are expected to be satisfied by the end of the current semester). The deadlines for scheduling this examination are indicated in §2. The student's advisory committee will conduct this examination.

5.7 The Application for Degree

Same as in §3.7.

5.8 Thesis

There is no thesis requirement. However, a student must take four hours of Math 702 that must involve the completion of an individual project. The topics of individual projects include, for example, analysis of financial time series data, pricing of financial derivatives via simulation, asset allocation optimization, or formulation of a solution to the problem encountered during a summer internship. The individual project should normally be completed by the end of the fourth semester of the student's work on the degree. The student's advisory committee consisting of three mathematics faculty members will supervise this project. A written project report should be submitted when the project is completed. The final MS examination must include an oral presentation by the student about the results of the project, with questions from the student's MS committee.

6 The MS in Mathematics (Mathematics Teaching Option)

6.1 Description and Learning Outcomes

This is a two-year professional degree designed to prepare teachers of mathematics at the community college, four-year college, or secondary levels. The program combines advanced work in mathematics with coursework in education and practice teaching, providing a foundation in both mathematical content and teaching methodology.

This MS program is designed to lead the student to the following learning outcomes:

1. Critical thinking: Students will have developed the skills necessary to critically read and evaluate both practitioner and research articles in mathematics education journals.
2. Pedagogical content knowledge: Students will have the mathematical knowledge necessary to teach upper secondary and lower college level mathematics.
3. Effective communication: Students will be able to speak effectively about mathematics, and write scholarly contributions to practitioner journals.

Departmental requirements and regulations for the Mathematics Teaching Option of the MS degree are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

6.2 Prerequisites

Same as in §3.2.

6.3 Courses and Hours

A candidate must complete 35 semester hours of approved graduate work, both in mathematical content and teaching methods. This must include 26-semester hours of graded course work.

(a) Mathematics Content

Required Courses: Math 500, 501, and at least four credits of Math 702

Mathematics Electives: at least one course must be included from each of the following three areas:

Algebra/Discrete Mathematics/Geometry: Math 505, 507, 509, 550, 553, 555

Probability/Statistics: Math 443, Stat 510, 519, 533, 544, 548, 549, 573

Applied/Numerical: Math 464, 466, 508, 540, 541, 548, 563, 564, 565, 566, 567, 570, 571, 574, 586

(b) Mathematics Education

Required Courses: Math 531, 532, 533

Teaching Practicum: Math 497 (1 semester, 2 credits), Math 597 (2 semesters)

6.4 Transfer Credit

Up to six hours of transfer credit may be given for suitable course work done at another university. Transfer credit is requested by listing the courses on the Program of Study (see §3.5); approval of the Program of Study implies approval of transfer of credit. Other general regulations regarding Transfer Credit can be found in Chapter 6 of the Graduate School Policies and Procedures Manual.

6.5 The Program of Study

Same as in §3.5.

6.6 The MS Examination

Each Master's student must pass a final oral examination that will cover all of the student's course work plus the content of Math 401–402 (analysis) and 420–421 (linear and abstract algebra) and include an oral presentation on the results of the student's Math 702 project. The student's advisory committee will conduct this examination.

6.7 The Application for Degree

Same as in §3.7.

6.8 Thesis

There is no thesis requirement. However, the student must complete four hours of Math 702. This involves independent study under the guidance of a faculty member, normally the chair of the student's advisory committee. The topic of the study must pertain to curricular and pedagogical issues relevant to teaching mathematics. The results of the project are usually summarized in a paper, although this is not mandatory.

7 The MS in Statistics

7.1 Description and Learning Outcomes

Students can enroll into the Masters of Science in Statistics program either directly or while seeking a PhD in another field at WSU (see §8).

This MS program is designed to lead the student to the following learning outcomes:

1. Problem solving skills: Students are expected to learn the fundamental tools of statistical modeling and implementation. Skills for identifying and solving statistical problems arising in various interdisciplinary areas is an important expected learning outcome associated with this degree.
2. Ability to work individually or in groups: Statistical modeling can be pursued at an individual level or as part of a group effort with the group comprised of experts in various allied fields. The students are expected to develop such skills so that modeling and analysis gets done in a timely and efficient manner.
3. Communication skills: Good communication skills are expected so that students can present in an effective manner the interpretation, as well as implications of the results obtained from a statistical model and its analysis.

Departmental requirements and regulations for the MS in Statistics are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

7.2 Prerequisites

Students considering the MS in Statistics should have a major in Mathematics, Statistics or a field in which statistics is heavily used. Students must adhere to Graduate School admission requirements, including a 3.0 grade point average during their last 60 hours of undergraduate study. Though not required, the Department strongly recommends submission of verbal and quantitative GRE scores.

The following list of courses form the basis for minimum admission requirements for the MS in Statistics degree program:

Prerequisites for Admission

- Math 171, 172, and 273 (Calculus I, II, and III, 3 semesters)
- Math 220 (Linear Algebra, 1 semester),
- At least one 3-credit course in computer programming
- Statistical Methods (3 credits)

In addition, the following courses are recommended by the Department as prerequisites for admission into the MS in Statistics degree program:

Recommended Prerequisites

- Math 401/402 (Analysis I and II) 2 semesters
- Math 420 (Linear Algebra II) 1 semester

7.3 Courses and Hours

Requirements for the Master of Science Degree in Statistics include: at least 30 credit hours of coursework of which 26 must be graded, 4 credits of Stat 702, a written special project, and passage of a comprehensive oral examination. Courses are chosen from five field areas: Advanced Theory and Stochastic Processes, Linear Models and Multivariate Analysis, Data Analysis, Bioinformatics and Biostatistics, and Econometrics and Time Series. The core requirements include Stat 443, 512, 530, 533, 556, at least one course in statistical computing (e.g., Stat 536), and a minimum of two credit hours of statistical consulting (Stat 590). The remainder of the 30 hours must include 3 or more courses from at least 2 field areas, chosen from the following:

- Advanced Theory and Stochastic Processes: Stat 544, 548, 549.
- Linear Models and Multivariate Analysis: Stat 519, 535, Math 516.
- Data Analysis: Stat 422, 428, 514, 536, 555, 572, 573.
- Bioinformatics and Biostatistics: Stat 520, 522, 565, Math 563.
- Econometrics and Time Series: Stat 508, 516, EconS 511, 512, 513.

Any changes to the above requirements for a particular student can be made only with prior approval of the students MS Committee and the Chair of the MGSC Committee. Special topics covered in Stat 510 may be used to satisfy some of the field area requirements with approval of the students committee. Students who do not have a background in a field outside of statistics, mathematics, or computer science are encouraged to take at least two courses in another substantive area.

7.4 The Program of Study

Same as in §3.5.

7.5 Transfer Credit

Credit appropriate to the program of study (with a grade of B or higher) earned in other accredited graduate schools after the award of the bachelors degree may be transferred and applied toward a students graduate degree program. The number of such credit hours is limited to no more than half of the total graded course credits required. Transfer credit is requested by listing the courses on the Program of Study (see §3.5); approval of the Program of Study implies approval of transfer of credit. Other general regulations regarding Transfer Credit can be found in Chapter 6 of the Graduate School Policies and Procedures Manual.

7.6 MS Committee and MS Project

There is no thesis requirement; however, an MS in Statistics student is required to do a special written Masters project equivalent to 2-4 hours of Stat 702. Therefore, early in the students graduate program (by the second semester as recommended by the Graduate School), he/she should obtain a project supervisor and formulate an MS committee. The students project supervisor will normally serve as the head of the MS committee, which will usually include two additional faculty

members with interest in Statistics. The student is required to make the final draft of the project report available to the MS committee at least two weeks prior to the final Masters oral exam. It is the committees responsibility to give final approval to the project.

7.7 The MS Examination

The final Masters oral exam is a two-hour oral exam conducted by the students M.S. committee. The oral exam will consist of (i) a 30-minute presentation of the students Masters project, (ii) a 15-minute period following the Masters project presentation for questions by the committee related to the results contained in the Masters project, and, (iii) a 75-minute period devoted to a comprehensive oral exam covering the material in Stat 443, Stat 512, Stat 530, Stat 533, Stat 556 as well as material covered in additional course work. The student is expected to be thoroughly familiar with a wide array of statistical concepts as contained in the list of topics and concepts obtained from the department.

7.8 The Application for Degree

Same as in §3.7.

8 The MS in Statistics for PhD's in Other Fields

8.1 Description and Learning Outcomes

There are many disciplines and sub disciplines that require extensive advanced training in statistics to perform graduate research work. One natural avenue for students at WSU to obtain this advanced training is to pursue an MS in Statistics. A number of students at WSU have chosen and continue to choose this option. It provides training they need to perform research in their primary field of study and such a degree enhances their marketability. All students enrolled in a PhD program in Pullman are able to receive advanced statistical training at the Master of Science level. The addition of the MS in Statistics degree will better prepare students to do research in their primary PhD degree-granting field. By pursuing this option, a student can simultaneously be enrolled in the MS in Statistics option and the program of their primary PhD degree-granting unit. The idea is to design a curriculum that satisfies the requirements of both the primary PhD degree-granting department and the MS in Statistics degree program. Subject to approval of their respective committees, any of the graded credits taken at WSU may be shared by both the MS and PhD programs. A thesis or written special project is required for the MS in Statistics and may be related to the PhD dissertation.

The learning outcomes for this degree are as in §7.1.

Departmental requirements and regulations for the MS in Statistics for PhD's in Other Fields are specified below. The regulations of the Graduate School for master's programs are available in the Graduate School Policies and Procedures Manual.

8.2 Admission Requirements

Although requirements vary from department to department, all students pursuing an MS in Statistics must have a background which is the equivalent of the following WSU Math courses: Calculus I, II, and III (Math 171, 172, 273), introductory Linear Algebra (Math 220), one 3-credit course in Computer Programming, and at least one 3-credit undergraduate course in Statistical Methods. In addition, Math 401, 402 (analysis I and II), and Math 420 (linear algebra II) or equivalent, are recommended.

8.3 Application Process

Students need to fill out an Application for Admission form with the Graduate School requesting the MS in Statistics degree option. There is no additional application fee. Students need to notify their primary department and the Department of Mathematics and Statistics of their intent to pursue this option prior to submission of their application. Note that the Department of Mathematics and Statistics does not usually provide assistanships to students who are getting a PhD in another department.

8.4 Graduation Requirements

For purposes of graduation, all students must complete the required graduate course work for both the MS in Statistics and their primary field of study. Requirements for the Master of Science Degree in Statistics include at least 30 credit hours of course work, 26 of which must be graded and

4 credits of Stat 702, passage of a comprehensive oral examination, and a thesis or written special project is required.

Courses are chosen from five field areas: Advanced Theory and Stochastic Processes, Linear Models and Multivariate Analysis, Data Analysis, Bioinformatics and Biostatistics, and Econometrics and Time Series. For both options, the core requirements include Stat 443, 512, 530, 533, 556, at least one course in statistical computing (e.g., Stat 536), and a minimum of two credit hours of statistical consulting (Stat 590). The remainder of the 30 hours must include a total of at least 3 courses from 2 field areas, chosen from the following:

- Advanced Theory and Stochastic Processes: Stat 544, 548, 549.
- Linear Models and Multivariate Analysis: Stat 519, 535, Math 516.
- Data Analysis: Stat 422, 428, 514, 536, 555, 572, 573.
- Bioinformatics and Biostatistics: Stat 520, 522, 565, Math 563.
- Econometrics and Time Series: Stat 508, 516, Econ S 511, 512, 513.

Any changes to the above requirements for a particular student can be made only with prior approval of the students MS Committee and the Chair of the MGSC Committee. Special topics covered in Stat 510 may be used to satisfy some of the field area requirements with approval of the students committee. Students who do not have a background in a field outside of statistics, mathematics, or computer science are encouraged to take at least two courses in another substantive area.

8.5 MS Committee and MS Project

A Program of Study must be submitted by the deadlines indicated in §2. The appropriate form is available at the Graduate School Office or may be downloaded from its web site.

In addition to the two primary advisors, the student should set up degree committees in both the primary department and the Department of Mathematics and Statistics. Normally, the Ph.D. committee in the students primary department will consist of three to five faculty members whereas the MS degree committee will be comprised of three faculty members from Mathematics and Statistics whose interests are primarily in Statistics. These committees will function independently in how they carry out unit requirements for the respective degree programs.

9 The Graduate Minor in Statistics

9.1 Description and Learning Outcomes

The Minor in Statistics provides students seeking a PhD in another field at WSU with the training needed to perform research in their primary field of study, and also enhances their marketability.

This graduate minor is designed to lead the student to the following learning outcomes:

1. Problem solving in area of research: Students are expected to possess skills to solve statistical problems arising in the area of their specialization.
2. Ability to work individually or in groups: Students are expected to develop skills necessary to carry out modeling and analysis at the individual level and in a group environment.
3. Communication skills: Good communication skills are expected so that students can present in an effective manner the interpretation, as well as implications of the results obtained from a statistical model and its analysis.

9.2 Application

To apply, PhD students must have the proposed minor approved by the Graduate Studies Committee of the Department of Mathematics and Statistics. To obtain the Graduate Minor in Statistics, a PhD student must indicate the Graduate Minor in Statistics on their Program of Study form. A Department of Mathematics and Statistics faculty member with interest primarily in Statistics is then appointed to the students Doctoral Committee. The program will need to be signed by not only your major department chair but also by the minor department chair.

9.3 Academic Requirements

A graduate minor in statistics requires a total of 15 hours, 12 of which must be at the graduate level. The prospective applicant specializes in one of two areas: theoretical or applied statistics. Theoretical statistics requires: STAT 443, STAT 556, one of: STAT 530, STAT 531, or STAT 533, and two additional 500 level statistics courses. Applied Statistics requires: five 500 level statistics courses or four 500 level statistic courses and STAT 443. Emphasis is on breadth, so credit toward the minor will only be given for courses that do not have a significant degree of overlap. The courses that are credited towards graduate minor in statistics shall have all been approved by the Mathematics and Statistics faculty member who is appointed to the students Doctoral Committee.

9.4 Preliminary and Final Doctoral Examinations

The preliminary examination is intended to cover both major and minor disciplines. The minor examination may be written or oral or both. The committee member from the minor department shall vote with the major department/program. There is no separation into major and minor fields during the final examination of the dissertation; all examiners vote on the total examination.

10 Summary of Procedures for PhD Degrees

Procedure	Under the Direction of	Date
Obtaining an advisor	Chair of the Graduate Studies Committee	As soon as possible after admission to Graduate School
Training on Responsible Conduct of Research Education	Graduate School See §15.1	As soon as possible after admission to Graduate School
GQE	Chair of the Graduate Studies Committee	See §11.5.1
Submission of Program of Study	Department Chair, Advisor, Doctoral Committee	See Navigating Your Degree
DQE	Doctoral committee	See §11.5.2 and §11.5.3
Scheduling of Preliminary Examination[a]	Mathematics and Statistics Department Chair, minor department chair, Graduate School	After approval and completion of a substantial portion of the Program of Study
Preliminary Examination	Mathematics and Statistics Graduate Faculty, Graduate Faculty of minor department	At least four months prior to the Final Oral Examination See §11.5.4
Application for degree[b]	Graduate School	See Navigating Your Degree
Scheduling of Final Examination[c]	Graduate School	See Navigating Your Degree
Final Oral Examination	Doctoral Committee, Department Chair, Graduate School	See Navigating Your Degree See §11.5.5
Final acceptance of archival manuscript and one copy of approved thesis[d]	Graduate School	5 work days after defense

NOTES: [a] Submit completed scheduling form with approval examination date, hour and place to the Graduate School **at least 10 working days prior to examination date.**

[b] It is strongly advised that the application for a degree be submitted **one semester before the final oral examination** is scheduled so that student can be notified of graduation requirements (to-do lists) before enrolling for their last semester.

[c] Submit completed scheduling form (including approved examination date, hour and place) and a copy of the thesis to the Graduate School Office at least 10 working days prior to the examination date. It is required that a copy of the dissertation be cleared by the Graduate School for compliance of format at the time of scheduling the final examination. A copy of the dissertation must be available for public inspection at least 5 working days prior to the final examination in the department office location designated by the department. The student must provide a copy of the dissertation to each member of the doctoral committee and to the Representative of the Graduate Studies Committee at least 5 working days before the date of the final examination.

[d] Doctoral students wishing to participate in Commencement must satisfy all requirements for the degree by the Wednesday preceding the Commencement.

All forms may be picked up in the Graduate School Office, or downloaded via the web.

ENROLLMENT: Students are responsible for satisfying all enrollment requirements stated in the Graduate School Policies and Procedures Manual and in §15 of this handbook.

11 The PhD in Mathematics

11.1 Description and Learning Outcomes

The degree of Doctor of Philosophy (PhD) in Mathematics is awarded in recognition of distinctive scholarship and original contributions to knowledge.

This PhD program is designed to lead the student to the following learning outcomes:

1. Critical Thinking: Students will be able to think critically and creatively.
2. Knowledge and Scholarship: Students will be able to identify and conduct original research and scholarship.
3. Ethical and Responsible Research: Students will be able to conduct research in an ethical and responsible manner.
4. Effective Communication: Students will be able to effectively communicate research work in written and oral form.

Departmental requirements and regulations for the PhD in Mathematics are specified below. The regulations of the Graduate School for doctoral programs are available in the Graduate School Policies and Procedures Manual. Appeals requesting waiver or modification of any rule of departmental origin may be submitted to the Graduate Studies Committee.

11.2 Prerequisites

Same as in §3.2.

11.3 Courses and Hours

This section contains information on course work requirements.
A student must successfully complete 72 hours of approved course work. Twenty four hours of course work must be chosen from the five groups below. This must ordinarily include at least two courses from each of three groups.

Group 0: Math 501, 502, 503, 504, 525
Group 1: Math 505, 507, 511, 550, 555
Group 2: Math 508, 512, 560, 561, 570, 571, 586
Group 3: Math 543, 544, 545, 546, 564, 565, 567, 574
Group 4: Math 563, 568, 569; Stat 533, 536, 544, 572, 573

At least four additional graded 400 or 500 level courses are required to meet the Graduate School requirement of 34 semester hours of graded course work beyond the bachelor's degree. Finally, all doctoral students are required to take one hour of Math 500 (to be taken before the student's first Fall semester) and 20 total hours of Math 800. Teaching assistants are required to take three semesters of Math 533 (Teaching College Mathematics).

11.4 Transfer Credit

Graduate credit earned elsewhere (excluding extension work, special problems, workshops, etc.) may be applied as part of the program if the work is of "A" or "B" quality. Transfer credit is

requested by listing the courses on the Program of Study (see §11.5.2); approval of the Program of Study implies approval of transfer of credit. Other general regulations regarding Transfer Credit can be found in Chapter 6 of the Graduate School Policies and Procedures Manual.

11.5 The Doctoral Examination Structure

This section contains information on examinations. Note that if a student fails to pass an exam after the allowed number of attempts, the program will notify the Graduate School to recommend disenrollment from the program.

The doctoral examination structure consists of four examinations: Graduate Qualifying Examination, Doctoral Qualifying Examination, Preliminary Doctoral Examination, and Final Doctoral Examination. The Graduate School Policy requires that all the students can have 2 (two) attempts to pass each examination. These examinations and the Program of Study are described below.

11.5.1 The Graduate Qualifying Examination (GQE)

The Graduate Qualifying Examination (GQE) is a single four-hour written examination based on undergraduate material covering advanced calculus (including vector calculus) and linear algebra. The GQE will be at the level of difficulty of upper division WSU mathematics courses. It will be 50% advanced calculus, 50% linear algebra. (Appendix A gives the list of topics.) The GQE will be prepared and graded by a committee of four faculty members chosen by the Chair of the Department. Rules concerning the GQE are:

(a) Students can take the GQE in the first semester of enrollment and have at most two subsequent attempts to pass the GQE.

(b) Students with a previous mathematics degree must pass the GQE by the end of their third semester in the Program (not counting summer semesters). All other students must pass the GQE by the end of their fourth semester in our Program (not counting summer semesters).

(c) The GQE will consist of ten problems and the student will be required to respond to all the problems.

(d) The GQE is typically given twice a year: (1) On the week **before** the Fall semester commences and (2) on the second day (Tuesday) of the Spring semester.

(e) Requests by students to view the graded exams, inquiries or any objections regarding the grading must be addressed to the Chair of the Graduate Studies Committee, who will act as a liaison between students and the GQE Committee.

11.5.2 The Program of Study

Soon after completion of the GQE a PhD candidate should choose an area of specialization and make arrangements for an appropriate faculty member to chair his/her Doctoral Committee. The Doctoral Committee, in consultation with the candidate, will decide upon a Program of Study and tentatively set a time for the Doctoral Qualifying Examination (see §11.5.3).

11.5.3 The Doctoral Qualifying Examination (DQE)

The Doctoral Qualifying Examination (DQE) is a written examination that covers the candidate's area of specialization with the focus on appropriate graduate course work. The student's Doctoral Committee will define the material to be covered on the DQE, compose and grade this examination. The candidate's Doctoral Committee and the candidate will jointly decide on the format of the DQE. Rules concerning the DQE are:

(a) Students will have at most two attempts to pass the DQE.

(b) Students are expected to pass the DQE by the end of their third semester (excluding summer sessions) after passing the GQE.

(c) The DQE will be given at a time suitable for the student and the committee.

11.5.4 The Preliminary Doctoral Examination (PDE)

The Preliminary Doctoral Examination (PDE) is an oral examination which follows the Graduate School rules for Preliminary Doctoral Examinations except for the following procedures. The PDE will begin with a presentation by the student to his/her doctoral committee on a thesis research problem and a plan of research to be followed toward its solution. The examination will include questions and feedback from members of the doctoral committee on the student's presentation. Rules concerning the PDE are:

(a) Students will have at most two attempts to pass the PDE.

(b) Students must pass the PDE by the end of their second semester after passing the DQE.

(c) The PDE will be given at a time suitable for the student and the committee.

11.5.5 The Final Doctoral Examination

The Final Doctoral Examination (FDE) will occur after the student has completed the thesis (see §11.6 or §14.6 as appropriate), and the thesis has been approved by the student's Doctoral Committee. It will be an oral examination following the rules of the Graduate School. The FDE is devoted mainly to a presentation of the content of the thesis by the student and includes questions from members of the doctoral committee.

Note that students who have not completed their doctoral degree (i.e., have not passed the FDE) within 3 years of the semester they passed their preliminary exam,or within 10 years from the beginning date of the earliest course applied toward the degree, **must request from the Graduate School an Extension of their degree program**.

11.6 The Thesis

Once one has passed the Preliminary Examination (see §11.5.4), one becomes technically a candidate for the PhD. This means that most of one's time should be given to specific preparation for, and writing of a doctoral thesis. The manner in which this is done must be left up to the student and the Doctoral Committee, especially the thesis advisor. In general, however, the thesis should include work, which, in originality, importance, and correctness, is good enough to appear in a research journal.

A paper will be prepared by the PhD candidate and submitted to a refereed journal, approved by the student's Doctoral Committee. The paper should ordinarily be based on portions of the candidate's PhD thesis. Acceptance of the paper is not a precondition for the completion of the degree work. A 2/3 majority of the candidate's Doctoral Committee can waive the requirement of a journal submission of a paper based on the thesis.

11.7 Teaching Experience

Most holders of graduate degrees in mathematics eventually teach in one way or another. Moreover, some experience with classroom teaching is useful in almost any mathematical career. The Department accordingly requires that each PhD student be responsible, under supervision, for teaching at least one undergraduate class for a semester. Since this responsibility may be preceded by teaching experience of a less autonomous kind (grading papers, assisting teachers in other ways, conducting help sessions, etc.), every graduate student should have at least one year of teaching experience in the broad sense. The total experience may be considered an apprenticeship in teaching and should be treated as seriously and responsibly as any other part of the student's program.

The terms of many fellowships, traineeships, and other forms of graduate student support permit participation in teaching programs where required. If a student holds a grant which does not permit such participation, then the student will need to combine the period of the grant with at least a year on terms permitting teaching, e.g., as a teaching assistant. This may mean holding the grant for less than the normal period.

11.8 Residence

The period of study for doctoral degrees is at least three years (six semesters) beyond the baccalaureate degree. For students entering a doctoral program without a master's degree, at least two of these three years must be in residence at WSU (enrolled full time and present on campus). For students entering a doctoral program with a master's degree, at least one of these three years must be in residence at WSU (enrolled full time and present on campus).

11.9 The Application for Degree

Same as in §3.7.

12 The PhD in Mathematics (Applied Mathematics Option)

12.1 Desscription and Learning Outcomes

The specialization of modern academic disciplines provides both a challenge to those who wish to do research at the interface of mathematics and its areas of application and many opportunities to make valuable contributions. The Applied Mathematics Option allows students from a range of backgrounds to pursue a traditional applied mathematics program, while retaining the option to thoroughly learn an area of application. Entering students may not necessarily have a bachelor's degree in Mathematics. However, they will be required to demonstrate a grasp of the core areas of advanced calculus and linear algebra at the level of a bachelor's degree in Mathematics. They will then be given great latitude to take specialized courses in Mathematics and their area of application.

The learning outcomes for this degree are as in §11.1.

Departmental requirements and regulations for the Applied Mathematics Option are specified below. The regulations of the Graduate School for doctoral programs are available in the Graduate School Policies and Procedures Manual. Appeals requesting waiver or modification of any rule of departmental origin may be submitted to the Graduate Studies Committee.

12.2 Prerequisites

Students who enter the Applied Mathematics Option of the Ph.D. program in Mathematics are expected to have quantitative backgrounds, including upper division course work in Mathematics. Ideally, this would include familiarity with advanced calculus and linear algebra at the upper division level. Students with a deficient background may take Analysis (Math 401 and 402 at WSU) or Linear Algebra (Math 420 at WSU). Students are expected to make up deficiencies at the earliest opportunity.

12.3 Courses and Hours

The course work requirements for the Applied Mathematics Option shall be as follows. A candidate must complete 34 semester hours of graded course work. These courses must be numbered 500 or above (except for up to 9 hours of non-graduate level graded course work). Twelve hours of course work must be chosen from the two groups below and must ordinarily include at least two courses from each group. A course appearing in more than one group may only count towards fulfilling the requirement in one of those groups.

> **Modelling and Applied Analysis:** Math 415, 508, 512, 523, 440/540, 441/541, 560, 561, 563, 568, 569, 570, 571, 574, 579, 586; Stat 533, 572, 573
>
> **Computational Mathematics and Optimization:** Math 464, 543, 544, 545, 546, 448/548, 564, 565, 566, 567, 574; Stat 533, 536, 544

In addition to the 12 hours chosen from the two groups, 12 further hours of Mathematics courses must be taken. These 12 further hours must be numbered 400 and above. Of this total 24 hours of required course work in Mathematics, at least 18 hours must be numbered 500 and above. Conjoint courses shall count as 400 level courses for these requirements. Exception to these requirements

may be recommended by the student's Doctoral Committee and must be approved by the Graduate Studies Committee.

All doctoral students are required to take one hour of Math 500 (to be taken before the student's first Fall semester), which will include short presentations by faculty on their research areas, and 20 total hours of Math 800. Teaching assistants are required to take three semesters of Math 533 (Teaching College Mathematics). Further course work may be required by the Program of Study, which will be assembled in consultation with the student's Doctoral Committee. Students are strongly encouraged to participate in the Applied Mathematics Seminar throughout their graduate studies.

12.4 Transfer Credit

Same as in §11.4.

12.5 Examinations

Same as in §11.5.

12.6 The Thesis

Same as in §11.6.

12.7 Teaching Experience

Same as in §11.7.

12.8 Residence

Same as in §11.8.

12.9 The Application for Degree

Same as in §3.7.

13 The PhD in Mathematics (Statistics Option)

13.1 Description and Learning Outcomes

The information revolution of the twenty-first century brings a strong need to analyze and interpret large data sets, and provides opportunities for those who wish to pursue their careers at the interface of mathematics, data analysis and computational science. The Statistics Option allows students with interdisciplinary backgrounds and interests in data science to pursue their doctorate degree in statistical methodology and its applications. Entering students need not necessarily have a bachelor's degree in Mathematics or Statistics. However, they will be required to demonstrate a grasp of the core areas of advanced calculus and linear algebra at the level of a bachelor's degree in Mathematics. They will then be given great latitude to take specialized courses in Statistics, Mathematics and their areas of application.

The learning outcomes for this degree are as in §11.1.

Departmental requirements and regulations for the Statistics Option are specified below. The regulations of the Graduate School for doctoral programs are available in the Graduate School Policies and Procedures Manual. Appeals requesting waiver or modification of any rule of departmental origin may be submitted to the Graduate Studies Committee.

13.2 Prerequisites

Students who enter the Statistics Option of the PhD. program in Mathematics are expected to have quantitative backgrounds, including upper division course work in Mathematics and Statistics. Ideally, this would include familiarity with advanced calculus, linear algebra, probability and statistics at the upper division level. Students with a deficient background may take any of Analysis (Math 401 and 402 at WSU), Linear Algebra (Math 420 at WSU), probability (Stat 443 at WSU) or Statistics (Stat 456 at WSU). Students are expected to make up deficiencies at the earliest opportunity.

13.3 Courses and Hours

The course work requirements for the Statistics Option shall be as follows. A candidate must complete 34 semester hours of graded course work. These courses must be numbered 500 or above (except for up to 9 hours of non-graduate level graded course work). Conjoint courses shall count as 400 level courses for these requirements. Of the total 34 hours of required graded course work, a student must take all of the following Core Statistical Theory and Methodology courses that account for 12 hours of course work. In addition to the core group, a student must also take at least 12 hours of graded course work from the Applied Statistics and Computational Mathematics group.

Core Statistical Theory and Methodology: Stat 533, 536, 548, 549

Applied Statistics and Computational Mathematics: Math 516, 548, 563, 575, 576; Stat 512, 514, 516, 519, 520, 522, 530, 535, 544, 555, 565, 572, 573

Exception to these requirements may be recommended by the student's Doctoral Committee and must be approved by the Graduate Studies Committee.

All doctoral students are required to take one hour of Math 500 (Proseminar), which will include short presentations by faculty on their research areas, and 20 total hours of Math 800. Teaching assistants are required to take three semesters of Math 533 (Teaching College Mathematics). Further course work may be required by the Program of Study, which will be assembled in consultation with the student's Doctoral Committee. Students are strongly encouraged to participate in the Probability and Statistics Seminar throughout their graduate studies.

13.4 Transfer Credit

Same as in §11.4.

13.5 Examinations

Same as in §11.5.

13.6 The Thesis

Same as in §11.6.

13.7 Teaching Experience

Same as in §11.7.

13.8 Residence

Same as in §11.8.

13.9 The Application for Degree

Same as in §3.7.

14 The PhD in Mathematics with Education Emphasis

14.1 Description and Learning Outcomes

The degree of PhD in Mathematics with Education Emphasis is awarded in recognition of scholarship and original contributions to the teaching and learning of mathematics. The main difference from the other PhD choices is in the research focus. The requirements for this PhD include competence in core mathematics as well as study in the research methodologies applicable to research in mathematics education.

This PhD program is designed to lead the student to the following learning outcomes:

1. Critical Thinking: Students will have a working knowledge of the literature in mathematics education research. They will understand different theories of learning mathematics and styles of research.

2. Knowledge and Scholarship: Students will have mastered the tools and knowledge (both mathematical and educational) necessary to conduct original research in mathematics education that will lead to a publishable quality dissertation.

3. Ethical and responsible research: Students will have completed the necessary training in ethical research and will fully understand and have experience with the issues involved in conducting educational research.

4. Effective communication: Students will be experienced in writing research-based journal articles, making research presentations at conferences and speaking frequently in front of their peers.

Departmental requirements and regulations for the PhD in Mathematics are specified below. The regulations of the Graduate School for doctoral programs are available in the Graduate School Policies and Procedures Manual. Appeals requesting waiver or modification of any rule of departmental origin may be submitted to the Graduate Studies Committee.

14.2 Prerequisites

Same as in §11.2.

14.3 Courses and Hours

The course work for the PhD in Mathematics with Education Emphasis shall be as follows. A candidate must successfully complete 72 hours of approved coursework. At least 34 semester hours must be graded coursework and numbered 500 or above (except for up to 9 hours of 400-level graded course work). All doctoral students are required to take one hour of Math 500 (to be taken before the student's first Fall semester) and 20 total hours of Math 800. Teaching assistants are required to take three semesters of Math 533 (Teaching College Mathematics).

The rest of the course work must include the following courses:

Core: Math 501, Math 511, Math 531, and Math 532

Foundation in Mathematics (5 courses from the following): 502, 503, 504, 505, 507, 512, 525, 543, 544, 553, 555 and 564. Alternative courses may be selected in consultation with your advisor. The intent here is to provide breadth of background in mathematics.

Educational Foundations, Research Methodologies, and Statistical Analysis: Math 534 (Learning Theories in Mathematics), Math 535 (Research Paradigms in Math Education), Ed Res 564 (Qualitative Research), and either Stat 520 (Statistical Analysis of Qualitative Data) or Stat 530 (Applied Linear Models).

It is also recommended that the student participate in the joint WSU/UI Mathematics Education Seminar each semester and take two or more additional graded math courses numbered 500 or above to strengthen the mathematical foundations.

14.4 Transfer Credit

Same as in §11.4.

14.5 Examinations

Same as in §11.5.

14.6 The Thesis

Same as in §11.6.

14.7 Teaching Experience

Same as in §11.7.

There are two additional requirements.

First, most students graduating with this degree will be expected to teach the equivalent of Math 251 and 252 when they are hired as faculty members. Thus, students earning this degree are required to do an internship with a Math 251 or 252 instructor during which they will become familiar with the manipulatives used to teach these courses and gain experience teaching and assessing pre-service elementary teachers in an activity-based environment.

Second, they will teach a 200-300 level mathematics course with serious mentoring by their advisor or another faculty member approved by the advisor. The intent here is to help candidates develop all aspects of their teaching skills in a more autonomous environment than calculus.

14.8 Residence

Same as in §11.8.

14.9 The Application for Degree

Same as in §11.9.

15 Important Policies and Regulations

The preceding parts of this guide outline the substance of the graduate programs in mathematics at WSU. Certain mechanisms and procedural rules are required, however, to implement individual programs. The present section summarizes the most important of these. These rules reflect both Graduate School and departmental policies. Refer to the Graduate School Policies and Procedures Manual for a complete specification of the rules originating from the Graduate School.

15.1 Responsible Conduct of Research Education

All graduate students are required to complete web-based training on Responsible Conduct of Research Education as soon as possible and inform the Graduate Program Coordinator of the Department that training has been completed. This training is mandatory and must be repeated after a five year period.

15.2 Graduate Student Code of Rights and Responsibilities

The Graduate Student Code of Rights and Responsibilities describes policies and guidelines pertaining to academic advancement and related grievance procedures, and provides links to important resources regarding student conduct, academic dishonesty, discrimination, sexual harassment and drug and alcohol policies.

15.3 Policy on Consensual Relationships

According to the The Executive Policy on Faculty-Student and Supervisor-Subordinate Relationships, faculty, graduate teaching and research assistants, as well as other supervisory employees in the WSU community accept responsibility to avoid any apparent or actual conflict of interest between their professional responsibilities and their personal relationships with students, or those whom they supervise, evaluate, or exercise other relationships of power or authority.

15.4 Enrollment

An aspirant for a graduate degree at WSU must meet all requirements for that degree during a period of continuous enrollment.

Normal course load is described in §15.5 below.

Students who do not wish to enroll for credit may enroll under graduate leave status. The student may not schedule examinations while being enrolled under graduate leave status.

Students not on appointment may carry reduced course loads during the final semester of their programs of study. Students on appointment however, must always carry the normal course load as described in §15.5, including in their final semester of study. See the Graduate School Policies and Procedures Manual for a complete specification of enrollment categories.

15.5 Course Load and Regulations

The following table indicates minimum and maximum numbers of credit hours for a graduate student at WSU stipulated by the Graduate School. Anything below the minimum is less than a

full load and must be approved by the advisor; anything above the maximum is an overload, and must be approved not only by the advisor, but also by the Dean of the Graduate School.

Semester	With no Assistantship		With Half-Time Assistantship	
	minimum	maximum	minimum	maximum
Fall, Spring	10	18	10	18
Summer (six-week sessions)	6	8	3	8
Summer (eight-week session)	8	10	3	10

The normal course load for a graduate student in the Department of Mathematics and Statistics must be consistent with the requirements in the table above, and in addition must satisfy the guidelines described in the next two paragraphs.

Students holding departmental assistantships during the academic year are expected to carry at least twelve (12) credit hours during the Fall and Spring Semesters. Students holding assistantships during any session of the Summer are expected to carry the minimum course load (see table above) during any one of the three Summer sessions. Any credits in excess of three (3) taken during the summer are the financial responsibility of the student. Students with no assistantships are expected to carry a course load that satisfies the requirements in the table above.

In addition, the courses that a graduate student takes during any semester must satisfy the set of regulations below, where the phrase "graduate-level course" means

- any course with the prefix Math[1] and a number from 501 to 590 (inclusive), or
- any course the prefix Stat[2] and a number from 507 to 590 (inclusive), or
- courses taught outside the Department specifically mentioned in graduate program descriptions in this handbook, or
- any course taught outside the Department (irrespective of number) vital to the student's program, if approved by the student's advisor.

Additional course regulations:

(a) All full-time graduate students should register for 702 (master's) or 800 (doctoral) research credits each semester as follows:

  - If a student has a thesis advisor already and is working on a research project, she/he should enroll for one (1) credit in the respective course under her/his advisor supervision.
  - If a student does not have a thesis advisor yet and is not doing research, she/he should enroll for one (1) credit in the respective course under the supervision of the Department Chair.
  - If students are taking preliminary or final exams, they must enroll in two (2) research credits for that semester.

[1] In the case of crosslisted Mathematics courses, graduate students with assistantships are expected to enroll under the prefix Math.

[2] In the case of crosslisted Statistics courses, graduate students with assistantships are expected to enroll under the prefix Stat.

(b) Until a doctoral student has passed the Graduate Qualifying Examination, she/he may **not** enroll in Math 800 beyond what is described in (a) above.

(c) Each graduate student with a Half-Time Assistantship from the Department of Mathematics and Statistics must enroll in at least nine (9) hours of graduate-level course work per semester (Fall and Spring), with the following exceptions:

- a first-year student, who finds it necessary to take an undergraduate course preparatory to taking a graduate level course, may substitute for a graduate-level course this undergraduate course (this may be done for more than one course);
- a doctoral student, having passed the Graduate Qualifying Examination may substitute up to three (3) hours of Math 600 for graduate-level course credit;
- a candidate for a doctoral degree who has passed the Doctoral Qualifying Examination is not required to enroll in any graded graduate-level course;
- a master's student who is enrolled in at least three (3) hours of Math 702 in the final semester of the master's program is not required to enroll in any graduate-level course.

15.6 Switching to or Adding a Graduate Program

Master's students who wish to change to a doctoral program must apply to the Department by filing the Plan and Degree Level Change Form. If such a change of program is approved, it is subject to the following rules:

- The outcome of any attempt to pass the GQE during the Master's course of studies is valid for the doctoral program and counts toward the maximum number of two attempts allowed to pass this exam.
- If applicable, the student must use her/his remaining attempts to pass the GQE on the next two available opportunities following the semester in which the switch to the doctoral program is approved.
- All other regulations and timing rules regarding the exams past the GQE (i.e., DQE, PDE and FDE) apply as described in the doctoral program.
- The total maximum period of financial support is as described in §17.2.

Doctoral students who want to obtain a Master's degree in the course of their studies must file a Plan and Degree Level Change Form to add the Master's program. Subsequently, a Program of Study for the Master's degree must also be submitted (four months before the final Master's examination).

15.7 Grades

In the grading system used at WSU, numerical equivalents of letter grades are:

	A := 4.0	A− := 3.7
B+ := 3.3	B := 3.0	B− := 2.7
C+ := 2.3	C := 2.0	C− := 1.7
D+ := 1.3	D := 1.0	
	F := 0.0	

The following rules govern grades for graduate students:

- to earn any degree, a student must have a 3.0 cumulative grade point average and 3.0 program grade point average;
- no course for which the student has received a grade below "B-" may be dropped from a degree program; program courses for which a "C-" or below has been received must be repeated, but not on a Pass/Fail basis;
- Termination of enrollment. The enrollment of a graduate student who fails to establish and maintain a cumulative GPA of 3.0 or above at the end of two semesters, one semester and one summer session, or two summer sessions will be terminated. The enrollment of a graduate student will be terminated if he/she fails to obtain a 2.75 cumulative GPA or above at the end of one semester or one summer session of graduate study.
- Reinstatement:
  - A graduate student who has completed only one semester or one summer session with a GPA below 2.75 may be reinstated upon favorable recommendation of the department/program chair and approval by the Dean of the Graduate School.
  - After a graduate student has completed two semesters, one semester and one summer session, or two summer sessions, the student must maintain at least a cumulative 3.0 GPA. If the GPA drops to the 2.75 to 2.99 range, the student may be reinstated by the Dean of the Graduate School only upon favorable recommendation of the department/program chair. The student will then have one semester or summer session to increase the cumulative GPA to 3.0. Failure to do so requires termination of enrollment. A graduate student who has completed two semesters, one semester and one summer session, or two summer sessions of graduate study and whose cumulative GPA is below 2.75 is not eligible for reinstatement.
- courses outside the department and not in the student's minor department may be taken on a Pass/Fail basis; this should be arranged at the time of registration by submitting the appropriate forms (obtainable at the Graduate School Office); the grade in any such course will be "Pass" or "Fail".

15.8 Advisor and Advisory/Doctoral Committee

The Chair of the Graduate Studies Committee assigns new graduate students an advisor, who, in consultation with appropriate people, helps the student prepare his/her program and recommend the composition of his/her MS Advisory or Doctoral Committee.

The composition of an MS Advisory or Doctoral committee is governed by

1. The Graduate School Policies and Procedures (see Masters Degree Requirements, part C on p. 66 and Doctoral Degree Requirements, part C on p. 73.)

2. The Graduate Program in Mathematics and Statistics Bylaws, as to who is a member of the Graduate Faculty and who can serve on student committees.

The Graduate School has issued the following general guidelines for the formation of committees:

MS Advisory

- The committee must have at least three WSU faculty members.
- All committee members must hold a degree of comparable level to the degree sought by the candidate.
- At minimum, the committee must have one tenured/tenure track faculty who is graduate faculty in the student's graduate program. The second member must be graduate faculty in the student's graduate program, but is not required to be permanent tenure track faculty. The third member may be from inside or outside of the student's graduate program, does not need to hold graduate faculty status, and does not need to be permanent tenure track faculty. The chair must be tenured/tenure track in the student's graduate program unless specified otherwise in the bylaws.
- Experts outside of WSU and faculty from other institutions may serve on committees as a fourth member.
- In all of the above cases, for any non-WSU committee member or for any non-tenured/non-tenure track faculty outside the student's graduate program, please submit a vitae and include a rationale to be reviewed for approval by the Dean of the Graduate School.
- Any exception to the composition noted above, or to program bylaws, requires a memo requesting an exception to policy.

Doctoral

- The committee must have at least three WSU faculty members.
- All committee members must hold a doctoral degree.
- At minimum, the committee must have two tenured/tenure-track faculty who are members of the graduate faculty in the student's graduate program. The third member must be graduate faculty in a WSU graduate program, but is not required to be permanent tenure track faculty.
- 4th COMMITTEE MEMBER:

  a. Experts outside of WSU and faculty from other institutions may serve on committees as a fourth member.

  b. If the statistics minor is chosen, a statistics faculty member must be represented as the 4th committee member
- In all of the above cases, for any non-WSU member, or for any non-tenured/non-tenure track faculty outside the student's graduate program, please attach a vitae and include a rationale to be reviewed for approval by the Dean of the Graduate School.
- Any exception to the composition noted above, or to program bylaws, requires a memo requesting an exception to policy.

The student usually has a definite voice in the formation of these committees and in exercising this privilege should consider the appropriateness of prospective members. An ideal committee should

be made up of people all of whom have special reasons to be interested in the student's program, but represent varying viewpoints.

Committees of both types are responsible for directing the student's program and conducting preliminary and final examinations of the student. Furthermore, the doctoral committee has the particularly important responsibility of guiding the student's thesis work and deciding on the acceptability of the finished thesis. Most of this responsibility usually falls on one member (normally the chair) of the doctoral committee, who, in this role, is called the student's thesis advisor or major professor.

15.9 Programs of Study

A Program of Study for each degree sought must be filed by the appropriate deadlines in §§ 2, 10. While this may be filed in the student's first semester at WSU, it is often more convenient to wait until later since program changes are practically inevitable. It is suggested that for a master's degree, this is filed in the second semester of graduate work, and for a doctoral degree, no later than four months before the Preliminary Examination is held. These programs are made out on forms obtainable from the Graduate School Office by the student, with advice from his/her advisor and, if applicable, a representative (usually the chair) of the minor department. After tentative approval by these persons, the program should be typed and one copy should be given to the Graduate School. Students will be notified of Program of Study approval by an email from the Graduate School. Programs should be made out thoughtfully, with due attention to all degree requirements, availability of courses, the student's special interests, etc. However, the program is not unalterably fixed when it is approved; program changes may be requested (on appropriate forms) and are normally approved when they are consistent with degree requirements and basic policy.

16 Other Useful Information

16.1 Annual Graduate Student Review

An annual progress review of each graduate student is performed at the end of the spring semester. The review takes place on a form with two parts provided by the department. Students complete part I of the form and his/her advisor completes part II. It is recommended that prior to completing this form, students meet with their advisors to discuss their progress. A sample of the annual review form can be found in §18.

16.2 Exceptions to Departmental Requirements and Regulations

Both the student and the student's committee have considerable latitude in meeting departmental and Graduate School requirements. When a waiver of a departmental requirement or suspension of a departmental regulation is desired, however, the student should transmit the request with a recommendation for action, to the Graduate Studies Committee. A written statement of the decision of the Graduate Studies Committee will be sent to the Department Chair, members of the Advisory Committee, and all members of the departmental graduate faculty. Decisions of the Graduate Studies Committee in such matters can be overruled only through action of the departmental graduate faculty. A meeting of the departmental graduate faculty will be called by the Chair of the Graduate Studies Committee to act on an appeal of such a decision when requested in writing by five members of the graduate faculty. The student must make appeals within 10 days of the decision by the Graduate Studies Committee.

16.3 Attendance at Departmental Colloquia

The Department organizes a colloquium series during the academic year. The colloquium presentations are usually made by leading scholars. The Department considers attending and participating in departmental colloquia as a vital part of the education of graduate students. Therefore, all graduate students are expected to attend the departmental colloquia.

16.4 Library Privileges

Mathematics and Statistics books and journals are housed in the Owen Science and Engineering Library. Other materials may be obtained by special order or by interlibrary loan or photocopy; the science librarians can supply information about these services. The library of the University of Idaho, which has a generous policy toward off-campus borrowers, contains some items not available at WSU, such as runs of certain journals. Every graduate student should become familiar with the arrangement and facilities of the science library. In particular, they should become familiar with accessing library resources electronically. Advanced graduate students should form the habit of scanning the latest issues of journals for items relevant to their research projects.

16.5 Summer Program

The Department of Mathematics and Statistics at WSU has a limited summer program. Our formal offerings for graduate students usually consist of a reading course and one or two regularly scheduled graduate courses. There are sometimes also informal seminars, which are open to anyone who is willing to participate.

We are, however, attempting to increase our summer offerings for the benefit of all concerned. Accordingly, everyone who is using the facilities of the department during the summer (especially those with financial support) will be expected to cooperate in this effort by enrolling in a course whenever possible.

16.6 Thesis Preparation and Approval

The Graduate School offers a document entitled "Dissertation Guidelines" which indicates, among other things, the proper format for the title page, signature page, and abstract of the dissertation. Another form required for a student preparing to schedule the final defense of the dissertation is the "Dissertation Acceptance Final Examination Scheduling" form, also available at the Graduate School Office.

The final rough draft of a doctoral thesis should be typed and enough copies made so that each member of the Doctoral Committee may read it, make corrections, and give approval. Once this approval has been obtained from the entire committee, preparation of the final typed copy should begin. *Departmental typists are not required to type theses.* A copy of the typed thesis must be presented at the Graduate School when the defense is scheduled. The student must pay all costs involved in the preparation and duplication of the manuscript, as well as all fees.

16.7 Times for Examinations

Preliminary and Final Examinations are not ordinarily scheduled for times when classes are not in session. See §§2, 10 for specific deadlines for examinations.

16.8 Final Procedures for Obtaining Graduate Degrees

There are several final formalities (e.g., application for degree) listed in the tables of §§2, 10 that need attention at the Graduate School when one plans to complete a graduate degree. Failure to attend to these by appropriate deadlines may postpone the granting of the degree. As a safeguard, a good rule of thumb is: any student who plans to receive a graduate degree at the end of a given semester should report to the Graduate School at the beginning of the previous semester to ascertain what final procedures need attention.

16.9 Professional Societies and Placement

As suggested in §1, one way a graduate student may express commitment to the profession and maintain contact with the rest of the mathematical world, is to join one or more professional societies. Most of these allow graduate students to enjoy all the privileges of memberships at reduced rates.

The organizations most likely to be of interest are probably:

- American Mathematical Society (research emphasis);
- Society for Industrial and Applied Mathematics (emphasis on applied mathematics);
- American Statistical Association;
- Mathematical Association of America (emphasis on collegiate mathematics);

- National Council of Teachers of Mathematics.

Job opportunities for mathematicians are undergoing considerable evolution. General as well as specific information about employment opportunities for mathematicians is available from the American Mathematical Society, the Society for Industrial and Applied Mathematics, and the Mathematical Association of America.

Most students expect to move into a suitable position immediately after the last academic degree is obtained, if not before. This sometimes calls for early and aggressive effort. Members of the faculty are glad to provide their help and advice.

Hard copies of announcements of job openings for mathematicians are placed in the Department (Hacker) Lounge, Neill 216, just as soon as they come in. Such announcements received electronically are forwarded to all graduate students as soon as they are received.

In general, finding the first employer in one's mathematical career is a challenging and momentous matter. A great deal of help is available from institutions and individuals, but ultimately, the initiative and the crucial decisions must come from the individual student.

17 Assistantships and other Awards

17.1 Research and Teaching Assistantships

Research and teaching assistantships serve primary purposes:

- to provide the assistant with financial aid while pursuing graduate studies;
- to give the assistant an opportunity for apprenticeship in research and teaching;
- to augment the research and teaching programs of the Department.

17.2 Terms for Research and Teaching Assistantships

The normal appointment to a research or teaching assistantship is considered a *half-time appointment*. Assistantship appointments are made on a semester-by-semester basis. Fall Semester appointments begin on August 16 while Spring Semester appointments begin on January 2. Summer appointments are sometimes available.

The assistantship salary will be determined as follows. Students with a master's degree in mathematics or statistics, or who have passed the departmental Graduate Qualifying Examination, will receive pay at Step 47 of the Graduate School Grid. (In the second case the new level of pay will be implemented starting from the semester following the one when the GQE took place). Other students will receive pay at the lower rate at Step 42 of the Graduate School Grid.

The Graduate Studies Committee reviews current academic standing and the level of performance in assistantship duties of each graduate student at the end of each semester. Continued financial support in the form of a teaching or research assistantship is available to students who remain in good academic standing in the Department of Mathematics and Statistics and perform their assistantship duties in a satisfactory manner.

The usual maximum periods of support (from the time of first enrollment in graduate studies in the Department) are as follows.

For students entering a doctoral program having satisfactorily completed all the requirements for a degree in mathematics or statistics:

- three semesters (excluding summer semesters) to pass the Graduate Qualifying Examination;
- six semesters (excluding summer semesters) to pass the Doctoral Qualifying Examination;
- eight semesters (excluding summer semesters) to pass the Preliminary Doctoral Examination.
- ten semesters (excluding summer semesters) to pass the Final Examination.

For all other students entering a graduate program:

- for master's candidates: two years;
- for doctoral candidates:
  - four semesters (excluding summer semesters) to pass the Graduate Qualifying Examination;

  - seven semesters (excluding summer semesters) to pass the Doctoral Qualifying Examination;
  - nine semesters (excluding summer semesters) to pass the Preliminary Doctoral Examination.
  - twelve semesters (excluding summer semesters) to pass the Final Examination;
- for master's candidates who decide to change to a doctoral program: the usual maximum period of support will be as if the student enrolled in the doctoral program on the date of first enrollment in the master's program.

17.3 Duties of Research Assistants

A research assistant is usually assigned to a particular member of the faculty, who then directs his/her work as assistant. In some departments, research assistants often literally assist the professor in research, but in mathematics this is seldom feasible and the research assistant is often engaged, in effect, on a separate project which may be more closely related to his/her thesis plans than to anything else.

17.4 Duties of Teaching Assistants

Teaching assistants may perform a wide variety of tasks, ranging from relatively routine paper grading to having complete charge of an individual class. In general, an effort is made to assign to teaching assistants tasks that will be of greatest benefit to them without neglecting the needs of the undergraduate students with whom they deal.

It is not always easy for a teaching assistant to arrive at a balance between activities as a student and activities as a teacher. The term "half-time" is probably misleading. Undergraduate teaching is an important function of the Department, and teaching assistants have a large share in it; they should accordingly avoid slighting it, and bring to it as much conscientiousness and imagination as they can.

Anything worth reading about college teaching in general, and about the teaching of college mathematics or statistics in particular, should be of potential interest to the teaching assistant. There exist some useful documents addressed directly to teaching assistants in mathematics, statistics and kindred disciplines. A good place to start is the web site of the Mathematical Association of America. Information useful to the teaching assistants is provided at Math 500—Proseminar, a course offered to teaching assistants in the week before Fall semester begins. All new graduate teaching assistants are encouraged to attend this seminar before they begin their assistantship duties. Math 597—Mathematics Instruction Seminar provides additional information useful for teaching assistants.

Teaching assistant appointments officially start on August 16 for Fall semesters and January 2 for Spring semesters. All teaching assistants are expected to be on-campus a minimum of four (seven for new teaching assistants) days before the start of each semester. Teaching assistants must not make travel plans that result in arrival in Pullman after the Wednesday preceding the start of each semester. Because of scheduling complications, assignments for teaching assistants are usually not available before the Wednesday preceding the start of each semester. However, once assignments are made, they will be posted on the departmental website and mailbox doors. Teaching assistants are expected to use the time remaining before the start of each semester to meet with course coordinators, prepare for teaching assignments, and prepare for coursework. Once

teaching assistant appointments for each semester have started (August 16 for Fall and January 2 for Spring), all teaching assistants must be available for contact via email (forwarded if necessary from a departmental email account) and/or an active telephone number.

Once a position has begun, the teaching assistant must maintain regular contact with his/her supervisor, via mail, email, phone, and/or office visits. If the position is primarily a grading position, the supervisor is the instructor for the associated course. If the position is a teaching or tutorial position the supervisor is the course coordinator for the associated course. All teaching assistants are assigned a mail box in Neill Hall outside the main office of the Department. All teaching assistants must check their Neill mail boxes and email frequently to ensure timely collection of student assignments, quizzes or tests for grading, and for other pertinent information. Graded material must be promptly returned to the supervisor by an agreed deadline. All grading must be completed following procedures and standards set by the supervisor. In case of an emergency that might prevent meeting a deadline, the supervisor must be notified as soon as possible. All teaching assistants are expected to hold office hours. Grader teaching assistants must work for two hours per week in help session labs organized by the Department. All teaching and tutorial teaching assistants must add one credit of Math 597 (Math Instruction Seminar) the first time that they teach/tutor a new course. There are separate Math 597 sections (led by course coordinators) for each of the primary teaching assistant assignment classes: Math 100/103, Math 107, Math 171 and Math 172.

Teaching assistants are expected to be on-campus until their teaching assistantship duties (including possibly the grading of final examinations and the submission of course grades) for the semester are complete. Teaching assistants should not make travel plans for an end-of-semester break that result in departures prior to the completion of their teaching assistantship duties for that semester.

All new teaching assistants are required to take three semesters of the one credit course Math 533: Teaching College Mathematics.

17.5 Departmental Policies Regarding Teaching Assistants

Teaching assistantships are critical to the existence of our graduate program. In many cases, the financial support they provide makes it possible for students to continue their education at the graduate level. With the assistantship comes the responsibility of conscientiously carrying out the TA duties. A major challenge for graduate students is to balance their own graduate studies with their TA duties.

The following guidelines have been developed to assist graduate students in achieving this balance:

1. Whenever possible, first year graduate students will be assigned to either lead calculus tutorials or grade for a lower division class. These positions will give the first year students slightly less responsibility and more time to adjust to graduate classes and to prepare for the GQE.

2. In the final semester of their doctoral work, students will be given more flexible TA duties to allow for completion of their dissertations, job interviews, and presentations at professional meetings.

3. Students in the middle of their doctoral program or the second year of their masters program will be assigned to teach courses in which they have more autonomy such as Math 105, 106, 107, 108, 201 or 202. Occasionally, more advanced courses such as 220, 273, and 315 will be available. This arrangement will give graduate students valuable teaching experience after they have acclimated to the graduate program and at a time when they have completed most of their course work.

4. TA teaching requests will be honored whenever possible within the constraints above. This will

include the opportunity to teach a variety of courses if the graduate student desires it.

5. TAs will receive support from their Course Coordinators in the form of sample course materials, course administration, test scheduling and planning, teaching observations and feedback, resolution of student problems, final grade approval, and so forth. For multiple section courses, regular meetings may be required, but normally should not exceed once a week.

17.6 Other Awards

There exist fellowships, traineeships, and other kinds of support for graduate students; these are provided by state, federal and private agencies. Graduate students at WSU are automatically considered for those administered at WSU, as these become available. Applications for awards not administered through WSU are left to the individual student, who may, however, count on the cooperation of the Department in these matters.

The variety of these awards, and the rapidity with which their terms change, make it impractical to list them here. A file of relevant announcements, lists, and application forms is maintained in the department office, and students should feel free to ask for it. A booklet, Fellowship and Research Opportunities in Mathematics, has appeared annually in recent years and may be obtained from the Division of Mathematical Sciences, National Research Council, 2101 Constitutional Avenue, N.W., Washington, D.C. 20418. Announcements about fellowships, etc., frequently appear in the Notices of the American Mathematical Society. The WSU Office of Grant and Research Development located on the 4th floor of Neill Hall can also be helpful. It is also possible to obtain long- and short-term loans on very favorable terms. Inquiries should be made at the Student Financial Aid Office.

18 Annual Student Review Form

The following form is provided here for your information only.

It is distributed to graduate students annually, near the end of the spring semester. It is mandatory that all students fill this form out according to the instructions and submit it to Ms. Linda Bentley by the set deadline.

2013-2014 GRADUATE STUDENT REVIEW (SAMPLE)

Instructions: *Students, you complete part I, then take to your advisor for him/her to complete part II. At that time make arrangements to meet with your advisor so that the two of you can discuss your progress. Faculty, please return form to student who will sign and bring it to the Mathematics Office in Neill 103, no later than May 3, 2013.*

Please print all replies.

I Student Section

Student Name: _____ Student ID Number: _____

Student's WSU Email Address: _____ Degree Sought: _____

Student's non-WSU Email Address: _____

GPA: _____

Student's Phone Number _____ Advisor's Name: _____

Year & Term Studies Began: _____ Has Program of Study Been Filed? _____

Exams -- PhD Students (Please refer to the Mathematics Graduate Student Handbook on the website regarding timely completion of your various exams.)

Please Enter Year and Semester Please include semester and year when these were completed.	Passed	Planned For (if known)
Graduate Qualifying Exam	_____	_____
Doctoral Qualifying Exam	_____	_____
Preliminary Doctoral Exam	_____	_____
Final Doctoral Exam	_____	_____

Professional activities since last review

Awards _____

_____

Meetings Attended

_____

_____

Publications

_____

_____

Presentations

_____

_____

Other

_____

_____

II Advisor Section

	Excellent	Good	Fair	Poor	N/A
Academic Performance					
Research Performance					
Rate of Progress					
Overall					

Comments:_____

_____

_____

_____

To the best of my knowledge, if this student is a TA or RA, this student has completed his/her duties as assigned and worked at least 20 hours per week.

Major Advisor Signature _____

Date _____

III Student Final Section Completion

My advisor met with me and we discussed this evaluation. I have the following comments:

_____

_____

_____

_____

Student Signature _____

Date _____

A Appendix: The Graduate Qualifying Examination (GQE)

A.1 General Comments

The GQE is set by an examining committee appointed by the Department Chair. The Chair of the Graduate Studies Committee, or his/her representative, administers the examination. A unique ID number is assigned to each examinee and only these ID numbers identify the examination papers. The names of the students will be correlated with the examination papers only after the final outcome of the examination has been determined.

Graded copies of the examination papers will be made available in the department office for inspection by the graduate faculty. Each paper will be marked with a consensus score for each problem, a consensus total score, appropriate comments, and the recommended outcome of the examination. After the graduate faculty has had at least a day to weigh the recommendations of the examining committee, the Graduate Faculty will convene to decide the final outcome of the examination for all participating students. It is inappropriate for members of the examining committee or other faculty members to discuss the performance of an examinee with any student, including the examinee, prior to the final announcement of the examination results.

A.2 Topics for the Graduate Qualifying Examination

Here are listed topics that a student should know for passing the GQE. Courses at WSU cover most, if not all, of these topics, but this list is not intended as a syllabus for any course. It is the student's responsibility to prepare adequately.

Topics in Advanced Calculus: Metric spaces, Cauchy sequences and completeness, limits, continuity, Intermediate Value Theorem, differentiation, Mean Value Theorem, Taylor's Theorem, L'Hospitâl's Rule, monotone functions, convexity and curvature, infinite series, sequences and series of functions, Fundamental Theorem of Calculus, Mean Value Theorem for integrals, improper integrals, partial and directional derivatives, Jacobian matrix, gradient vector, chain rule, Divergence Theorem, Stokes' Theorem, Inverse Function Theorem, Implicit Function Theorem, change of variables in multiple integrals, Lagrange multipliers.

References: This material is covered at the appropriate level, for example, in the following texts: T. Kaplan, *Advanced Calculus*, Addison-Wesley, 2002; A. Taylor and W. R. Mann, *Advanced Calculus*, Wiley, 1983; W. A. J. Kosmala, *A Friendly Introduction to Analysis—Single and Multivariable*, Pearson Prentice Hall, 2004.

Topics in Linear Algebra: Vector spaces, subspaces, linear independence, bases and dimension, inner product spaces, norms, triangle inequality, Cauchy-Schwarz inequality, orthogonality, orthonormal bases, orthogonal projections, basic matrix operations, matrix transpose, trace of a matrix, determinants and their properties, invertibility, eigenvalues and eigenvectors, characteristic polynomials, matrix equivalence, matrix similarity, diagonalizability, linear transformations, matrix representations of linear transformations, range and null space (kernel) of a linear transformation, symmetric and hermitian matrices or operators, unitary matrices, normal matrices.

References: This material is covered at the appropriate level, for example, in S. H. Friedberg, A. J. Insel, and L. E. Spence, *Linear Algebra*, Pearson Prentice Hall, 2003; P. J. Oliver and C. Shakiban, *Applied Linear Algebra*, Pearson Prentice Hall, 2006.