DEPARTMENT OF MATHEMATICS
MASTER'S OF SCIENCE IN MATHEMATICS HANDBOOK

FRESNO STATE

Discovery. Diversity. Distinction.

Contents

Welcome

Dear Student:

Welcome to the graduate program in Mathematics at California State University, Fresno. You have taken your first step towards a greater mastery of mathematics, a field that is not only a discipline, in and of itself, of breadth, depth, and beauty, but is also an indispensable tool for science, engineering, economics, business, and many more fields of study. In fact, today's mathematicians are involved in a diverse range of activities, from traditional teaching and classical mathematical research to aspects of climate modeling, biostatistics, econometrics, genetic engineering, and data science. As a result, the employment opportunities and challenges for individuals holding an advanced degree in the mathematical sciences are varied and plentiful.

Our Master's program has been designed to prepare students for this broad range of career opportunities and the challenges of the 21st century. Moreover, for those who wish to pursue a Ph.D. in the mathematical sciences, our coursework, together with the research opportunities available to our students, provide rigorous preparation for future matriculation in a doctoral program.

The Department of Mathematics at California State University, Fresno is committed to the highest standards of teaching, and offers courses for mathematics, science, engineering, and liberal studies majors, as well as general education mathematics courses for all majors. The Mathematics Department has 19 tenured and tenure-track professors specializing in a wide range of research areas, such as group theory, probability and statistics, applied mathematics, math biology, geometry, complex analysis, functional analysis, and topology.

This handbook has been prepared to help you through your journey as a graduate student, giving an overview of the master's program and describing its requirements. In addition, the handbook contains various policies of the graduate program, a list of faculty and their areas of research, and a list of graduate courses.

As a student in our Master's program, you should meet periodically with me to discuss your progress in the program, as well as any other issues that may arise. I can be reached by e-mail at `ovega@csufresno.edu`, by telephone at 559.278.4903, and in person in my office in Peters Building, Room 352.

Congratulations on your entry into our graduate program, and best wishes for your success!

Oscar Vega
Graduate Coordinator

General Information

Introduction

The Department of Mathematics at Fresno State offers a Master's of Science degree (M.S.). This program is ideal for individuals who are interested in working in business or industry, teaching at a community college, or earning a doctoral degree in the mathematical sciences (including Mathematics Education) at some later date. Also, our program would be useful for those who wish to assume a leadership role in high school teaching, and beyond.

Admission to the Program

In order to be admitted to the program, an applicant must have earned a Bachelor's degree, preferably in Mathematics. In order to achieve classified standing (i.e., full admission), applicants should have undergraduate preparation in mathematics comparable to that of a typical mathematics major at Fresno State and have a 3.0 grade point average in the their upper division mathematics courses (our main focus is on MATH 111, MATH 151, MATH 152, and MATH 171, or equivalent). Applicants lacking the above preparation may be admitted conditionally. These students will become classified after meeting additional requirements as set by the Graduate Coordinator. Coursework required to achieve classified status may not be applied towards credits for the graduate program.

All applicants are required to either:

- take the GRE Mathematics subject test. Applicants' GRE Mathematics subject test scores are expected to be at least 500; or

- complete, within the previous five years of your application to our program, courses on: upper division linear algebra, abstract algebra, and real analysis, all with at least a B and an average of 3.3 (that is, at least one A in these courses).

In addition, two (current) letters of recommendation, in letterhead, from faculty at the applicant's undergraduate institution are required. Letters should be sent directly to the Graduate Coordinator via email (letter writers: please use an institutional email for this) or via regular mail at:

Dr. Oscar Vega
Department of Mathematics
California State University, Fresno
5245 North Backer Avenue, M/S PB108
Fresno, CA 93740-8001.

To be admitted to the Master's of Science program in Mathematics, you must first apply to the University through Cal State Apply. In addition to completing the application online and sending two letters of recommendation to the Graduate Coordinator, you must also send to the appropriate admissions office:

- GRE subject official scores (if applicable), and
- one official transcript for each college and/or university attended.

Domestic students send documents to:	International students mail documents to:
California State University, Fresno Graduate Admissions Office 5241 N. Maple Ave M/S TA51 Fresno, CA 93740-8026	California State University, Fresno International Student Services & Programs 5150 N. Maple Ave. M/S JA56 Fresno, CA 93740 USA

If you are admitted as conditionally classified, it is your responsibility to:

- meet with the Graduate Coordinator to discuss any conditions to your full admission (i.e., to achieving classified standing);

- satisfy the noted conditions; and
- have the Graduate Coordinator submit verification that you have met all of the conditions to the Division of Research and Graduate Studies for approval as a student in classified graduate standing.

Support

The Department of Mathematics provides a variety of opportunities for students to assist them in their studies. With fewer than 25 students in the current graduate program, study tracks are facilitated with much greater ease than with larger programs. Graduate students will find that with a rich faculty-to-student ratio, faculty mentoring is individualized and tailor-made to their needs. Whether preparing for work in industry, high school and/or community college teaching, or doctoral studies, our faculty is committed to the support of our students.

Financially, students may qualify for aid after the completion of their first semester. Many of our graduate students are supported each semester by Teaching Associate positions, which usually require 10-20 hours of work per week, with pay that ranges approximately from $5,825 to $15,660 per academic year, depending on the total assigned work hours. A limited number of partial tuition fee waivers may also be available to outstanding applicants.

Additional information regarding financial support may be found on the Division of Research and Graduate Studies website.

Faculty

Our full-time faculty body represents a wide range of theoretical and applied orientations that include most of the major areas in mathematics and mathematics education. They are active in research and have projects that are suitable for student involvement. We have 20 outstanding full-time professors, the majority of whom have taught graduate courses. They are:

T. Rajee Amarasinghe, Ph.D., Indiana University, Bloomington.
Areas of research: interdisciplinary mathematics, technology in learning mathematics, ethnomathematics.

Earvin Balderama, Ph.D., University of California, Los Angeles.
Areas of research: spatial statistics, Bayesian methods, point processes, extreme value analysis, sports statistics.

Mario Banuelos, Ph.D., University of California, Merced.
Areas of research: applied mathematics, mathematical biology, data science and machine learning.

Mario Bencomo, Ph.D., Rice University.
Areas of research: engineering, applied, and computational mathematics, inverse problems, mathematical programming

Michael Bishop, Ph.D., University of Arizona.
Areas of research: mathematical physics, probability, functional analysis.

Lance Burger, Ph.D., Oregon State University.
Areas of research: teacher education, advanced mathematical thinking, philosophy of mathematics education.

Carmen Caprau, Ph.D., University of Iowa.
Areas of research: quantum topology, knot theory, categorifications of knot invariants.

Steve Chung, Ph.D., Florida State University, Tallahassee.
Areas of research: applied statistics, semi-parametric and nonparametric volatility models, financial time series.

Stefaan Delcroix, Ph.D., Rijksuniversiteit, Gent, Belgium.
Areas of research: finite groups, abstract algebra, coding theory, number theory.

Doreen De Leon, Ph.D., University of California, Los Angeles.
Areas of research: numerical analysis, applied mathematics.

Comlan de Souza, Ph.D., Southern Illinois University.

Areas of research: Fourier analysis, digital signal processing, phase recovery.

Tamás Forgács, Ph.D., University of Illinois at Urbana-Champaign.
Areas of research: several complex variables, differential geometry, health economics, mathematical economics.

Katherine Kelm, Ph.D., University of Oregon.
Areas of research: algebraic topology, low-dimensional homotopy, CW complexes.

Yaomingxin Lu, Ph.D. Western Michigan University
Areas of research: mathematical teaching and learning, problem solving and proving, technology use in teaching and learning, students' productive struggles, inquiry-based learning.

Marat Markin, Ph.D., National Academy of Sciences of Ukraine, Ukraine.
Areas of research: functional analysis; operator theory; differential equations in abstract spaces; semigroups of operators.

Maria Nogin, Ph.D., University of Rochester.
Areas of research: Topological semantics of modal logics; dynamic topological systems; algebraic topology; cohomology of groups; group extensions.

Khang Tran, Ph.D., University of Illinois at Urbana-Champaign.
Areas of research: complex analysis; analytic number theory; zero distribution; hypergeometric and basic hypergeometric series.

Agnes Tuska, Ph.D., Ohio State University.
Areas of research: use of technology in mathematics education, concept formation, secondary mathematics teacher education.

Oscar Vega, Ph.D., University of Iowa.
Areas of research: combinatorics, finite geometries, graph theory.

Ke Wu, Ph.D., Texas Tech University.
Areas of research: applied statistics, statistical and mathematical computing.

Requirements

The Master's of Science in Mathematics program has two types of requirements: Appropriate coursework and other benchmarks that students must hit at certain specific times in the program.

Note that a period of 5 years is allowed for the completion of all requirements for the Master's degree; that is, no coursework older than 5 years may be used to satisfy the requirements.

Course Requirements

Our program requires that you complete 30 units of coursework.

Core courses (6 units)

- MATH 251: Abstract Algebra
- MATH 271: Real Analysis

Additional courses (6 units)

- Choose one of the following: MATH 200, MATH 232, MATH 252, or MATH 272;
- Choose one of the following: MATH 223, MATH 228, or MATH 260.

Elective courses (15 units)

A combination of approved courses[1]

[1] Under the direction of the department graduate coordinator, each candidate should prepare and submit for approval a program of courses as early as possible.

Culminating experience (3 units)

- MATH 298: Research Project in Mathematics, OR
- MATH 299: Thesis in Mathematics

What You Should Know Before Enrolling in MATH 251 and MATH 271[2]

- **MATH 251:** Students should understand and be able to write rigorous proofs in Number Theory and Abstract Algebra. Knowledge of Linear Algebra is also required. A short list of topics that students should be familiar with follows: $\mathbb{Z}$ and $\mathbb{Z}_n$; vector spaces; normal subgroups; group homomorphisms; S_n, A_n, D_n, Q_8, and other small-order groups; matrix groups; Lagrange's Theorem; rings; ideals; ring homomorphisms; and fields.
- **MATH 271:** Students should understand and be able to apply topics of calculus (equivalent to MATH 75, 76, and 77 at Fresno State), as well as be at ease with advanced analytical proof techniques. They should have a thorough working understanding of sequences and series and have rudimentary knowledge of basic topology, equivalent to that encountered in MATH 171 and MATH 172 at Fresno State.

Graduate Writing Requirement

In order to satisfy the University Graduate Writing Skills Requirement, the student must submit a formal paper demonstrating writing skill in mathematics at the graduate level. This graduate level paper may be a research proposal, a literature review in some mathematical area of interest, a paper from a directed research project, or some other paper that meets the objectives for the writing requirement as stated in the Satisfaction of the Graduate Writing Requirement section of this Handbook. Deadlines are also given in that section.

Before attempting to satisfy the graduate writing requirement, the student must have

- achieved classified standing, and

[2]MATH 251 is only offered during the spring semester and MATH 271 is only offered during the fall semester.

- attended a Plagiarism Workshop and signed the Mathematics Department's Honor Code Statement Regarding Academic Integrity and Plagiarism.

It is recommended that students attend the Plagiarism Workshop as early as possible.

Advancement to Candidacy

You must advance to candidacy no later than the semester prior to graduation. It is recommended that you do this within the first 9 to 15 units of your program coursework (which should be completed by the end of the second semester).

To petition for advancement to candidacy you must have:

- achieved classified graduate standing;
- satisfied the University Graduate Writing Skills Requirement; and
- completed at least 9 units of your program at Fresno State, maintaining a 3.0 grade point average.

Once these conditions have been met, the candidate must meet with the Mathematics Graduate Coordinator and complete the Petition of Advancement to Candidacy for the Graduate Degree form. The completed form must be submitted within the first six weeks of the semester (at least one semester prior to graduation).

Culminating Experience and Graduation

The last semester prior to graduation, the candidate must do the following:

- **(a)** Enroll in MATH 298. This course is the Master's Project that must be completed under the supervision of a faculty member. The course culminates in a written and oral report to the department; OR
  (b) Enroll in MATH 299. This course is the Master's Thesis that must be completed under the supervision of a faculty member. The course culminates in a written and oral report to the department, and a written report to the University.

- Within the first week of the semester, the candidate must file a request through the Division of Research and Graduate Studies for the Master's degree to be granted by filling out and submitting a Graduate Degree Application.

There are several differences between a Project and a Thesis. The main ones are:

- a Thesis must consist of original research in an area of mathematics or mathematics education, and that a project could consist of work that does not yield new results but that is a complete literature review of a specific topic, or topics. These 'bibliographical projects' should not just be a compilation of information found in other sources but it should incorporate a thorough analysis and commentary.

- the deadline to submit a Thesis is usually about a month earlier than the deadline to submit a Project. A set of guidelines for the Master's Project may be found in this handbook, and the guidelines for the Master's Thesis may be found on the Division of Research and Graduate Studies' Thesis website.

Students are encouraged to think ahead and start looking for a Project/Thesis topic and advisor at least two semesters before when they will enroll in their culminating experience. Our Department maintains two webpages to help students in this process: (1) a list of all our faculty's areas of expertise, and (2) a list of all recent Master's theses our program has produced.

Students who are starting to work on their Thesis/Project may contact the Graduate Coordinator to request a LaTeX template that they may use to typeset their work. Projects/Theses in Mathematics Education can use a Word template, which is also available from the graduate coordinator (project) or the Division of Research and Graduate Studies' Thesis website.

Road Maps

In the following four pages, there are examples of road maps for students entering our program in odd or even years, and considering whether they have already taken MATH 172, or equivalent, at the time they start their Master's at Fresno State.

Sample Roadmap. M.S. in Mathematics.

Students starting in an ODD year that have taken **MATH 172**[3]

This guide is an unofficial document intended to be used for advising and course planning. This document cannot be used to waive or supersede requirements listed in the catalog. Fulfillment of all University requirements will be determined by the office of the Registrar.
This guide assumes that the student

- has satisfied and/or transferred from other institutions, if applicable, all the coursework typical of a Math major at Fresno State. In particular, the student has received at least a B in MATH 151, MATH 152, and MATH 171 or equivalent.
- has passed **MATH 172** or equivalent.
- the student plans to complete their Masters degree in four semesters.

For students who deviate from any of these assumptions. Please consult the graduate coordinator for modifications that need to be made to this guide to fit their particular case.

FALL ODD	
MATH 201	Cognition in Math Education
MATH 216T	Topics in Number Theory
MATH 252	Abstract Algebra II
MATH 271	Real Analysis
MATH 1XX	
Sign Honor Code Form	

SPRING EVEN	
MATH 220	Coding Theory
MATH 251	Abstract Algebra I
MATH 260	Modern Geometry
MATH 272	Functional Analysis
MATH 1XX	
Graduate Writing Requirement	

FALL EVEN	
MATH 200	Research Methods in Math Education
MATH 232	Mathematical Models with Technology
MATH 263	Point-set Topology
MATH 290	Independent Study
MATH 1XX	
Advancement to Candidacy	

SPRING ODD	
MATH 223	Applied Operator Theory
MATH 228	Functions of a Complex Variable
MATH 291T	Seminar
MATH 298/299	Project/Thesis in Mathematics
MATH 1XX	
Apply for Graduation	

You may take up to 9 units of undergraduate courses
You may take up to 6 units of independent study
You need to take, at least, ten courses to graduate

On green, courses you must take
On purple, activities you need to get done
You must take at least one blue course
You must take at least one peach course

[3] or equivalent course.

Sample Roadmap. M.S. in Mathematics.

Students starting in an ODD year that have NOT taken **MATH 172**[4]

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This guide assumes that the student

- has satisfied and/or transferred from other institutions, if applicable, all the coursework typical of a Math major at Fresno State. In particular, the student has received at least a B in MATH 151, MATH 152, and MATH 171 or equivalent.
- has not taken, or has not passed, **MATH 172** or equivalent.
- the student plans to complete their Masters degree in four semesters.

For students who deviate from any of these assumptions. Please consult the graduate coordinator for modifications that need to be made to this guide to fit their particular case.

FALL ODD	
MATH 201	Cognition in Math Education
MATH 216T	Topics in Number Theory
MATH 252	Abstract Algebra II
MATH 1XX	
Sign Honor Code Form	

SPRING EVEN	
MATH 220	Coding Theory
MATH 251	Abstract Algebra I
MATH 260	Modern Geometry
MATH 172	Intermediate Mathematical Analysis II
Graduate Writing Requirement	

FALL EVEN	
MATH 200	Research Methods in Math Education
MATH 232	Mathematical Models with Technology
MATH 263	Point-set Topology
MATH 271	Real Analysis
MATH 290	Independent Study
Advancement to Candidacy	

SPRING ODD	
MATH 223	Applied Operator Theory
MATH 228	Functions of a Complex Variable
MATH 291T	Seminar
MATH 298/299	Project/Thesis in Mathematics
MATH 1XX	
Apply for Graduation	

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[4] or equivalent course.

Sample Roadmap. M.S. in Mathematics.

Students starting in an EVEN year that have taken **MATH 172**[5]

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This guide assumes that the student

- has satisfied and/or transferred from other institutions, if applicable, all the coursework typical of a Math major at Fresno State. In particular, the student has received at least a B in MATH 151, MATH 152, and MATH 171 or equivalent.
- has passed **MATH 172** or equivalent.
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FALL EVEN	
MATH 200	Research Methods in Math Education
MATH 232	Mathematical Models with Technology
MATH 263	Point-set Topology
MATH 271	Real Analysis
MATH 1XX	
Sign Honor Code Form	

SPRING ODD	
MATH 223	Applied Operator Theory
MATH 228	Functions of a Complex Variable
MATH 251	Abstract Algebra I
MATH 291T	Seminar
MATH 1XX	
Graduate Writing Requirement	

FALL ODD	
MATH 201	Cognition in Math Education
MATH 216T	Topics in Number Theory
MATH 252	Abstract Algebra II
MATH 290	Independent Study
MATH 1XX	
Advancement to Candidacy	

SPRING EVEN	
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MATH 260	Modern Geometry
MATH 272	Functional Analysis
MATH 298/299	Project/Thesis in Mathematics
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[5] or equivalent course.

Sample Roadmap. M.S. in Mathematics.

Students starting in an EVEN year that have NOT taken **MATH 172**[6]

This guide is an unofficial document intended to be used for advising and course planning. This document cannot be used to waive or supersede requirements listed in the catalog. Fulfillment of all University requirements will be determined by the office of the Registrar.
This guide assumes that the student

- has satisfied and/or transferred from other institutions, if applicable, all the coursework typical of a Math major at Fresno State. In particular, the student has received at least a B in MATH 151, MATH 152, and MATH 171 or equivalent.
- has not taken, or has not passed, **MATH 172** or equivalent.
- the student plans to complete their Masters degree in four semesters.

For students who deviate from any of these assumptions. Please consult the graduate coordinator for modifications that need to be made to this guide to fit their particular case.

FALL EVEN	
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MATH 1XX	
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MATH 228	Functions of a Complex Variable
MATH 251	Abstract Algebra I
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MATH 172	Intermediate Mathematical Analysis II
Graduate Writing Requirement	

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[6] or equivalent course.

Relevant Policies

Satisfaction of the Graduate Writing Requirement

The graduate writing requirement must be satisfied before the student submits a petition to advance to candidacy. A graduate student may attempt to satisfy the graduate writing requirement at any time after the student has done the following:

- signed the Mathematics Department's Honor Code Statement Regarding Academic Integrity and Plagiarism, and
- achieved classified graduate standing,

pursuant to the submission deadlines below.

In order to meet the writing requirement, the student must submit a formal paper that is at least 10 full pages of text (not including tables and figures) and no more than 15, including abstract and not including references. The paper must be written using the department's **mandatory** GWR template, which students can request from the Graduate Coordinator. The GWR paper must demonstrate writing skill in mathematics at the graduate level, and it may be a research proposal, a literature review in some mathematical area of interest (or mathematics education), a paper from a directed research project, or some other math-themed paper that meets the objectives for the writing requirement, as discussed below.

A paper that has been submitted for a grade in a previous course, including for a Senior Project or Independent Study, is not eligible to fulfill the Graduate Writing Requirement. A GWR paper on a topic similar to that of a paper previously submitted for a grade must have

significantly updated content, as judged by the GWR Committee. In this case, the student must submit a copy of the original paper along with their GWR paper. If the changes are not considered sufficiently substantial by the GWR Committee, the paper will be considered to fail the GWR.

If a student has taken, or is currently taking, a MATH 290 course in Pure Mathematics, Applied Mathematics, Statistics or Mathematics Education at the time of their GWR submission, then their GWR paper must be on a topic in the same general area (Pure, Applied, Statistics, or Mathematics Education).

The student's writing should demonstrate:

- Clear organization and presentation of ideas;
- Understanding of the topic discussed in the paper;
- The ability to organize ideas logically so as to establish a sound scholarly argument based on appropriate use of mathematics. More specifically, the paper should include at least the statement of a substantial mathematical result and its proof, or a critical analysis of a substantial mathematics education, statistical, or applied mathematics result;
- Thoroughness and competence in documentation (i.e., proper use of references); and
- The ability to express in writing a critical analysis of existing scholarly/professional literature in some mathematical area of interest.

The paper must be submitted by e-mail to the Graduate Coordinator by the first Friday of the semester. After its submission, it will be distributed to a three-member review committee chosen each year by the Department Chair. The review committee will complete its review of the paper within two weeks of the submission deadline. Feedback will be sent to the student no later than one week after the review of the paper.

The paper will be scored using a rubric $(1-5)$ in each of four areas:

I. Style and Format;

II. Mechanics;

III. Content and Organization; and

IV. Integration and Critical Analysis.

The scoring rubric appears at the end of this document. The minimal acceptable combined score from all of the four areas (I-IV) is 12 points (a mean of 3 (Satisfactory) rating on each section), with no less than a score of 2 (Developing) on any one section[7]. Any student whose score in two or more of the four areas is 2 or less will be required to spend a total of 8 hours with a tutor in the Graduate Writing Center before re-submitting their paper. Attendance at such sessions will be reported to the Graduate Coordinator to ensure compliance.
Also, if a student does not hand in a draft by the first deadline they will be assigned a 0 in each category, and thus they will have to abide to the rules mentioned above.

The review committee will also provide comments to the student, including justification for the scores and possible suggestions for improvement (e.g., seek tutoring, improve analysis, etc.).

Students who fail their first attempt will have to resubmit an edited paper by the Friday of the fourth week of instruction of the same semester to the original review committee.

Students who fail their second attempt, have two options:

- Resubmit an edited paper by the Friday of the tenth week of instruction of the same semester to the original review committee; or
- Appeal – a new committee will be selected to review the student's submission.

Students who fail to complete the writing requirement after availing themselves of one of the three options above must take the course ENGL 160W (Writing Workshop) or an alternative acceptable to the Graduate Coordinator. In the semester immediately after taking this course, the student must submit a new document for evaluation to the current review committee no later than the submission deadline (first Friday of the semester). The new document cannot

[7]Scores, per area, are computed by averaging the scores assigned by the GWR committee members (not rounded up)

be a revision of the original submission. The main focus, or essence, of the paper must be significantly different from the original paper and its revision. Students who fail the writing requirement in this second cycle will be dismissed from the mathematics graduate program.

Failure to submit a GWR paper by any of the deadlines mentioned above will be construed as failing the writing requirement altogether, and the student will be dismissed from the mathematics graduate program.

Plagiarism in the completion of this, or any other written work, is unacceptable, and may lead to suspension or dismissal from the University.

Scoring Rubric Used to Evaluate the Satisfaction of the Graduate Writing Requirement.

I. Style and Format

5. Exemplary: In addition to meeting the requirements for a "4", the paper consistently models the language and conventions used in scholarly writing in the student's area of study. In other words, the manuscript's style and format are at the level required for a publication in a peer-reviewed journal.

4. Accomplished: While there may be minor errors, standard conventions for style and format are used consistently throughout the paper. The paper has an abstract, an introduction to the topic, and a conclusion. The paper demonstrates thoroughness and competence in documenting sources; the reader would have little difficulty referring back to cited sources. Style and format help make the paper understandable to the reader.

3. Satisfactory: A standard style and format is broadly followed, but inconsistencies and/or other errors are apparent. There may be references to less suitable mathematics sources (non-peer reviewed literature, web information). Weak transitions and apparent logic gaps may occur between topics being addressed. The style may be difficult to follow so as to detract from the comprehensibility of the paper.

2. Developing: While some mathematics conventions are followed, others are not. The paper lacks consistency of style and/or format. It may be unclear which references are direct quotes and which are paraphrased. Based on the information provided, the reader would have some difficulty referring back to cited sources. Significant revisions would contribute to the comprehensibility of the paper.

1. Beginning: The stylistic conventions of mathematics writing are not followed. The paper fails to demonstrate thoroughness and competence in documentation. Inappropriate style and format make reading and comprehensibility problematic.

II. Mechanics

5. Exemplary: In addition to meeting the requirements for a "4", the paper is essentially error-free in terms of mechanics. Writing flows smoothly from one idea to another. Transitions effectively establish a sound scholarly argument and aid the reader in following the writer's logic.

4. Accomplished: While there may be minor errors, the paper follows normal conventions of spelling and grammar throughout. Errors do not significantly interfere with topic comprehensibility. Transitions and organizational structures such as headings and subheadings are effectively used to help the reader move from one point to another.

3. Satisfactory: Grammatical conventions are generally used, but inconsistency and/or errors in their use result in weak, but still apparent, connections between topics in the formulation of the argument. There is poor or improper use of headings and related features to keep the reader on track within the topic. Effective mathematics vocabulary is used.

2. Developing: Frequent errors in spelling, grammar (such as subject/verb agreements and tense), sentence structure, and/or other writing conventions make reading difficult and interfere with comprehensibility. There is some confusion in the proper use of mathematical terms. Writing does not flow smoothly from point to point; appropriate transitions are lacking.

1. Beginning: The paper contains numerous errors in spelling, grammar, and/or sentence structure, which make following the logic of the paper extremely difficult. Mathematical terms are frequently misused.

III. Content and Organization

5. Exemplary: In addition to meeting the requirements for a "4", the paper excels in the organization and representation of ideas related to its mathematical topic. The paper illustrates mastery of the topic and conveys to the reader the student's understanding of the material.

4. Accomplished: The paper follows all requirements. The mathematical topic is carefully focused, and the paper clearly outlines and discusses the major points related to the topic. Ideas are logically arranged and rigorously presented, resulting in a sound scholarly argument. The paper is interesting and holds the reader's attention. The paper does a credible job summarizing related literature. General ideas are expanded upon in a logical manner. The work clearly goes beyond simply restating known ideas.

3. Satisfactory: The paper summarizes known concepts but has little expansion beyond restatement of known ideas. Certain logical connections or specific topics related to the paper's subject area may be omitted. Ideas and concepts are generally satisfactorily presented, although lapses in logic, rigor, and/or organization are apparent. The paper suitably introduces the reader to the topic being presented.

2. Developing: The paper is logically and thematically coherent, but is lacking in substantial ways. The mathematical rigor may be somewhat lacking, or the scholarly argument may be weak or poorly conceived. Major ideas related to the content may be ignored or inadequately explored. Overall, the content and organization needs significant revision to represent a critical analysis of the topic.

1. Beginning: Analysis of existing scholarly/professional literature on the topic is inadequate. The paper lacks mathematical rigor and is poorly organized. The reader is left with little information about, or understanding of, the paper's topic.

IV. Integration and Critical Analysis

5. Exemplary: The document presents a well-organized and fully-developed logical presentation, including clear analysis and synthesis of information from the various references. The paper evidences substantial, logical, and concrete development of ideas. References come from appropriate peer-reviewed journals or books. The paper illustrates a complete grasp of the proof methodology presented in the papers or books. The essential findings of multiple sources are accurately and concisely paraphrased, analyzed, and integrated. Original sources are clearly identified and correctly cited in both the body of the text and the reference section. Organizationally, smooth and effective transitions between topics lead the reader through an orderly discussion of the topic being addressed. If a research proposal is being presented, then the document presents the current state of knowledge for the topic being addressed using a variety of references. In addition, the gaps in current knowledge are clearly identified and significant directions and approaches that fill these gaps are identified.

4. Accomplished: There are inconsistencies in the organization and/or logic of the presentation, but still a clear analysis of the presented materials. While synthesis of all aspects of the topic may show varying degrees of development, the overall consistency, thoroughness, and analysis result in a well-crafted document.

3. Satisfactory: Identification of key topics or uncertainties in the paper's area may be incomplete. Although the paper synthesizes ideas from references, analysis of the information may be poorly developed or lacking. Complex topics and related concepts are awkwardly presented and linkages among topics may be unclear.

2. Developing: Weakness is evident in the coverage of the paper's area and analysis of information from the references, resulting in incorrect or poorly developed synthesis of results. Analysis is limited to summarizing mathematical topics. The result is a degradation of the paper, and the evidence of knowledge gaps.

1. Beginning: The paper contains numerous flaws in the essential components of a literature

review. The paper lacks a successful synthesis of disparate works, and there is no logical flow to the presentation. These issues result in a paper with limited comprehensibility and utility in illustrating the author's effective grasp of the material.

Policy on Academic Probation and Disqualification

According to University policy, a graduate student is immediately disqualified from the University and program when their grade point average (GPA) falls below 2.0 in any semester. A student whose GPA falls below 3.0, but is above 2.0, is placed on academic probation. A student who is placed on academic probation for any two semesters (not necessarily consecutive) will be disqualified from the University and program. A disqualified student who wishes to re-enroll in the university and program MUST file a Petition for Readmission with the Mathematics Department.

The relevant GPA to determine standing is the cumulative GPA for graduate students who have not been advanced to candidacy. The program GPA determines the standing of graduate students who have been advanced to candidacy with an approved program on file.

Upon notification of disqualification, the student must make an appointment to meet with the Graduate Coordinator to discuss their situation and determine if any extenuating circumstances exist that mitigate the disqualification. If disqualification applies, the student must prepare and file the Petition for Readmission packet, as outlined below, with the Graduate Coordinator.

If disqualification applies, students should file their petition as soon as they receive notification of disqualified status if they want to request to be readmitted in the next semester.

The petition packet must include:

- the Petition for Readmission (form found on the Division of Graduate Studies website);
- a 1-page typed letter of appeal explaining the circumstances that affected the GPA;
- supporting documentation of any extenuating circumstances; and
- strong letters of support from at least 2 graduate program instructors who know the student's work (submitted directly, via email, to the Graduate Coordinator).

The Graduate Coordinator will distribute the petition materials to members of the Department Graduate Committee. Petitions that are filed by the first day of the fall or spring semester

will be reviewed at a special meeting of the Graduate Committee scheduled for this purpose during the first week of classes to make it feasible for a student to be reinstated if the petition is approved. If there has been no break in enrollment, no application to the university is required. Petitions submitted after the first day of the semester will be reviewed at least two weeks before the application deadline for the following semester.

The Department Graduate Committee is responsible for making the recommendation on whether a student will be approved or denied for readmission. The Graduate Coordinator will send a decision letter to the student; if readmission is approved, any conditions are specified in this letter. The original petition, signed by the Graduate Coordinator, is submitted to the University Registrar's office with copies to Graduate Admissions and Division of Graduate Studies. A copy of the decision letter, specifying any conditions, is also sent to the Division of Graduate Studies.

The Graduate Coordinator will monitor disqualified readmitted students to ensure that they meet the conditions that they are expected to meet. In addition to specific conditions set by the program in its decision letter, a readmitted disqualified student must meet the University Graduate Committee requirement of earning a term GPA of at least 3.5 in each subsequent term until he/she attains a cumulative GPA of 3.0 (good standing) to avoid disqualification in the following semester(s). (The University Graduate Committee suggests that readmitted disqualified students generally not take new 200-level courses; they may, however, repeat 200-level courses that they did not pass. Note that graduate students are not eligible for grade substitutions. In addition, no more than 9 units a semester should be attempted. However, the plan/conditions are determined by the Department Graduate Committee.)

A graduate student may appeal the decision of the Department Graduate Committee (e.g., denial of the Petition for Readmission or the conditions of readmission) in writing to the Chair of the Department of Mathematics. This letter should be included in a packet containing the documents provided in the Petition for Readmission. If necessary, further appeals may be made to higher administrative levels in the following sequence after review at each level: Dean of the College of Science and Mathematics, Dean of Graduate Studies, Provost of the University.

Note: Per University policy, disqualified graduate students who choose not to petition for readmission, leave the university, and at some later point, re-apply to Fresno State, will be denied admission based on the disqualification. Such a student must file a Petition for Readmission and should not pursue the "Special Admission" process.

Guidelines for Master's Projects in Mathematics

The master's research project in mathematics should represent independent investigation into either mathematics education or a topic in advanced mathematics that is not covered in a standard course. A project includes a written project report and an oral presentation.

Before beginning work on a master's project, the student must form a project committee, in consultation with the Graduate Coordinator and the Project Advisor, consisting of the Project Advisor and two additional faculty members, at least one of whom must be a mathematics department faculty member. The Graduate Coordinator must approve of this committee, and be informed in writing of the nature of the project, before the student enrolls in MATH 298.

The Project committee must be kept apprised of the student's progress on the project, including:

- Being given a description of the nature of the project within the first two weeks of the commencement of the project.
- Being updated at least (a) at the middle of the semester, and (b) three-quarters of the way through the semester, regarding the student's progress on the project. These updates may be accomplished by providing the committee with a current draft of the written project report or an oral report or presentation.
- Being given a final draft of the written report (unbound) for review at least one week before the oral presentation.

If the majority of the Project committee members does not approve the project after reviewing the final report due to significant deficiencies, then the student will not be permitted to present his/her project and, thus, will not be able to graduate in the current semester. The committee will provide the student with a list of the deficiencies of his/her project which must be corrected to make the student's project acceptable, and, once these revisions are made, the project will be re-evaluated.

The written report should follow these guidelines:

- The final version (unbound) of the written report must be submitted to the Project committee and the Graduate Coordinator for review at least one week before the oral presentation.
- Two bound copies of the report must be prepared and submitted to the Graduate Coordinator at the time of the oral presentation.
- The bound copies of the written report must contain a signature page that is signed by all three members of the Project committee.
- The format of the title page of the project report and the signature page must be obtained from the Graduate Coordinator.
- The report should be self-contained and understandable to anyone with an advanced mathematical background.
- The report must represent your own, independent work. Plagiarism will not be tolerated.
- The written report must be typeset and double-spaced.
- A well-written report will contain
  - a title page,
  - the signature page;
  - an abstract;
  - a table of contents,
  - an introduction,
  - a main body,
  - a conclusion, and
  - a bibliography.

The oral presentation must:

- be approximately a 45 minute presentation that clearly summarizes the project or research done, followed by a question and answer session; and

- demonstrate a thorough understanding of the researched topic.

Graduate Courses

MATH 200. Research Methods in Mathematics Education (3 units)
This course covers quantitative and qualitative methods of researching how people think and learn about mathematics, and how research informs the teaching of mathematics. Content includes research design, use of statistical analyses, and critical examination of research in mathematics education.

MATH 201. Cognition in Mathematics (3 units)
This course explores theories and empirical studies which examine the development of students' and teachers' knowledge and practices in mathematics. A central theme of the course is the examination of research on the use of technology in the teaching of mathematics.

MATH 216T. Topics in Number Theory (3 units; max total 6 units)
Prerequisite: MATH 116. An investigation of topics having either historical or current research interest in the field of number theory.

MATH 220. Coding Theory (3 units)
Prerequisites: MATH 151 and MATH 152. Basic concepts in coding theory, properties of linear and non-linear codes, standard decoding algorithms, cyclic codes, BCH-codes.

MATH 223. Applied Operator Theory (3 units)
Prerequisite: graduate standing or permission of instructor. Fundamentals of abstract spaces and spectral theory of operators with applications. Resolvent set and spectrum of a linear operator. Bounded and unbounded linear operators. Compact operators and the Fredholm alternative. Symmetry and self-adjointness.

MATH 228. Functions of a Complex Variable (3 units)

Prerequisite: MATH 128. Representation theorems of Weierstrass and Mittag-Leffler, normal families, conformal mapping and Riemann mapping theorem, analytic continuation, Dirichlet problem.

MATH 232. Mathematical Models with Technology (3 units)

Prerequisite: graduate standing in mathematics or permission of instructor. A technology-assisted study of the mathematics used to model phenomena in statistics, natural science, and engineering.

MATH 251. Abstract Algebra I (3 units)

Prerequisite: MATH 151 or permission of instructor. Semi-direct products of groups; isomorphism theorems. Group actions; Sylow theorems; classification of groups of small order; finitely generated Abelian groups. Rings and ideals; quotient rings; domains (ED, PID, UFD); polynomial rings.

MATH 252. Abstract Algebra II (3 units)

Prerequisite: MATH 251. Field extensions; automorphisms of fields; Galois theory. Additional topics to be chosen from (1) modules, (2) linear and multilinear algebra and (3) representation theory.

MATH 260. Perspectives in Geometry (3 units)

Prerequisite: MATH 151 and MATH 152 or permission of instructor. Geometry from a transformations point of view. Projective geometry: theorems of Ceva, Menelaus, Desargues, and Pappus; conics; coordinatization. Transformations of the plane (Euclidean and projective); tessellations; wallpaper groups. Further topics to be selected from Incidence Geometry, Differential Geometry, or Algebraic Geometry.

MATH 263. Point Set Topology (3 units)

Prerequisite: MATH 172. Basic concepts of point set topology, set theory, topological spaces, continuous functions; connectivity, compactness and separation properties of spaces. Topics selected from function spaces, metrization, dimension theory.

MATH 271. Real Analysis (3 units)

Prerequisite: MATH 172. Lebesgue's measure and integration theory on the real line. Limit theorems and types of convergence. L_p spaces. Differentiation and integration.

MATH 272. Functional Analysis (3 units)

Prerequisite: MATH 271 or permission of instructor. Elements of the theory of abstract spaces. The three fundamental principles of linear functional analysis (Hahn-Banach Theorem, Uniform Boundedness Principle, and Open Mapping Theorem) and their implications. Duality and reflexivity of normed vector spaces, geometry of Hilbert spaces.

MATH 290. Independent Study (1-3 units; max total 6 units)

See Academic Placement – Independent Study. Approved for RP grading.

MATH 291T. Seminar (1-3 units; max total 6 units)

Prerequisite: graduate standing. Seminar covering special topics in an area of mathematical research.

MATH 298. Research Project in Mathematics (3 units)

Prerequisite: graduate standing. Independent investigation of advanced character as the culminating requirement for the master's degree. Approved for RP grading. Requirements for project.

MATH 299. Thesis in Mathematics (3 units)

Prerequisite: See Criteria for Thesis and Project. Preparation, completion, and submission of an acceptable thesis for the master's degree. Approved for RP grading.