Ph.D. Student Handbook

University of Northern Colorado
School of Mathematical Sciences

Version 3.2

April 23, 2015

"It is not knowledge, but the act of learning, not possession but the act of getting there, which grants the greatest enjoyment."

—Karl Friedrich Gauss, 1808

Changes from previous versions of this document:

Version 3.2 Updated dissertation defense timeline to current University policy. Updated Math comprehensive exam standards to reflect the newer comp policy.

Version 3.1 Updated links. Removed description of old comp policies. Updated Master's en Route information.

Version 3.0 Updated references to the graduate school webpage. Changed the UNC Catalog Program Requirements to match the current catalog. Updated the rotation of classes. Clarified Program Progress Review policy. Updated summer support policy. Added information about the new written comp policy and our transition to this policy. Clarified information about Master's en route plan of study.

Version 2.1 Clarified the policy on the grade required in core math classes that are not comped over.

Version 2.0 Added sections on Graduate Teaching Award and Oral Comps. Updated catalog description and policy on written comps. Added Table of the normal rotation of classes. Added sample two-year plans for Master's en route program.

Contents

1 Preface

It is expected that you and your advisors will consult this handbook at several pivotal points in your program:

- when you first enroll;
- when you prepare your Plan of Study;
- when you are ready to petition the Graduate School to take your written and oral comprehensive exams;
- when you select a doctoral advisor and a dissertation topic;
- when you begin writing your dissertation;
- when you are preparing to defend your dissertation;
- when you are preparing to graduate.

Try to stay at least one step ahead, by acquainting yourself with the policies that affect both your current and future activities. Some specific examples of cases in which you must plan ahead include: establishing resident status for tuition purposes by your second year; scheduling your statistics courses early in your Plan of Study so that Med 701 and its prerequisites are completed before written comprehensive exams are administered; changing your advisor and selecting your doctoral committee one semester in advance of taking comprehensive exams; submitting your proposal for approval to the IRB if it involves human subjects; and notifying the Graduate School of graduation one semester in advance of the ceremony.

1.1 Other sources of information

This handbook is a summary of the School of Mathematical Sciences and Graduate School policies pertaining to the Educational Mathematics doctoral program. No single document can cover all contingencies, however. For additional information, you can also consult the primary sources from which some parts of this handbook were constructed:

- The UNC Catalog for the year that you enrolled in the program. Available at `http://catalog.unco.edu`.

- The UNC Graduate School website. Available at `http://www.unco.edu/grad/`.

You should also know that the Graduate School maintains a list of deadlines for graduate students on the above site. This publication gives the deadlines for submission of various documents for the next several years.

If you wish to contact the Graduate School directly for answers to your questions at any time, their phone number is 351-2831. The Graduate School offers an orientation seminar to new graduate students at the beginning of each academic year that you can attend periodically to remain current with their policies. School of Mathematical Sciences polices are set by the School's Graduate Committee, which has a student representative whom you can contact for current information concerning pending changes that could affect your program.

This handbook is intended to clarify, not replace, the official UNC Catalog. If the statements herein contradict School of Mathematical Sciences or Graduate School policies, those policies take precedence. It is the student's responsibility to refer to the UNC catalog and the UNC Graduate School website for further guidance, and to become familiar with all School of Mathematical Sciences and Graduate School policies pertaining to this program.

School of Mathematical Sciences forms referred to in this handbook can be obtained from the School office. Graduate School forms can be obtained on-line at the UNC Graduate School website at

`http://www.unco.edu/grad/forms/index.html`.

1.2 Timeline for the Educational Mathematics Ph.D. Program

The following is meant to give you a suggested and customary timeline to advance through the program. However, a Ph.D. program is always individualized and your timeline may vary substantially from these suggestions. We generally guarantee support for four years for students making good progress on their programs, and extensions may be available. (See Appendix A.2 for details.) Most of the steps in this timeline are discussed in much greater detail later in this document.

First Year:

- Take steps to establish residency as soon as you arrive. (See Section 2.2.)
- Submit Plan of Study by early second semester. (See Section 3.1.)
- Apply for summer research support each spring. (See Section 4.2.)
- Submit annual report each spring for Program Progress Review until you pass your Orals. Evaluation is done on course performance, teaching, and general progress in the program. (See Section 4.1.)

Second Year:

- Research Advisor and Doctoral Committee selected by end of semester before comps (Graduate School form). (See Section 5.1.)
- Request comprehensive exams for following summer (School of Mathematical Sciences form). (See Section 5.2.)
- Plan or conduct pilot study in consultation with your research advisor.
- Submit annual report each spring for Program Progress Review until you pass your Orals. Evaluation is done on course performance, teaching, and general progress in the program. (See Section 4.1.)
- Written Comprehensive Exams summer of second year. Report on pass or fail made to Graduate School by Graduate Coordinator. (See Section 5.3.)

Third and Fourth Years:

- Continuous Enrollment Policy: Graduate students must enroll for at least one credit hour each academic semester (fall and spring) from the first term they first enroll in the program until the semester they graduate. Requests for exception must be made to the Graduate School.
- Oral Comprehensive Exams: Orals can be scheduled once a pass has been reported to the Graduate School on your written exams. A student must submit a Request to Schedule Doctoral Examinations no later than 14 calendar days before the exam date.

(Graduate School form). Results are reported by the Oral Examination Committee, which is normally the same as your Doctoral Committee. (See Section 5.4.)

- Dissertation Proposal hours (Math 797): You need 4 hours. You can register for 797 before completion of the written comprehensive exams if you have a Doctoral Committee formed and with the approval of your Research Advisor. (See Section 6.1.)
- Dissertation Proposal Defense: Scheduled when you and your Research Advisor agree you have completed the first three chapters of your dissertation (Graduate School form). (See Section 6.1.)
- Admission to Candidacy: Doctoral students advance to candidacy once they have passed written and oral comps, completed four hours of 797, and successfully defended their proposal. No student can be graduated sooner than the semester after he or she is admitted to candidacy. This step is handled automatically by the Graduate School. (See Section 6.2.)
- Dissertation hours (MATH 799): You need at least 12 hours of 799. You must be admitted to candidacy to register for MATH 799. (See Section 6.3.)
- Dissertation Defense: Scheduled when you and your Research Advisor agree you have completed the dissertation and are ready to defend it before your Doctoral Committee. Normally you must give your committee members at least two weeks to read your dissertation. The defense date must be no sooner than two weeks after the request is made. The defense must occur at least five weeks (35 calendar days) before the anticipated graduation date. (See Section 6.4.)
- Report of the Dissertation Defense (Graduate School form)
- Graduate: Apply to Graduate School. Note that deadlines for applying to graduate come before the start of the semester in which you intend to graduate.

The maximum time limit for completion of the doctoral program is eight years beginning with the earliest course work counted in the program (including transfer credit). Extensions for a semester can be requested from the Graduate School.

2 AT THE BEGINNING OF THE DOCTORAL PROGRAM

2.1 Admission to the Graduate School

A student applies for admission to our program by completing and submitting the Application for Admission forms required by the Graduate School.

These forms can be found on the Graduate School website at `http://www.unco.edu/grad/prospective/applying.html`.

In addition to meeting the Graduate School requirements, an applicant must submit an essay of approximately 500 words addressing their interest in this specific degree program and their educational goals. Applicants should possess a Master's degree in mathematics or in mathematics education with a strong mathematics component. Applicants with a Bachelor's degree in mathematics but without a Master's degree are welcome to apply to our Master's en route program. This Master's program is designed to prepare students with a bachelor's degree for our Ph.D. program. See Appendix B for details of the Master's en route program.

2.2 Establishing Residency

Upon admission into the doctoral program, it is wise to immediately set in motion the steps that will establish your status as a resident of Colorado for tuition purposes in subsequent years. Consult the University website `http://www.unco.edu/regrec/Residency/index.html` for information on the key steps needed to qualify for this status. Resident status has vitally important financial benefits for both you and the University. Do not neglect this important step, even if you are supported by a financial aid package. After the first year, all U.S. citizens will receive only a tuition waiver for the tuition cost of a Colorado resident. The additional cost as an out-of-state resident will be paid by you if you fail to establish residency.

According to Colorado state law, "An individual has to have been domiciled in Colorado for one calendar year before he/she is entitled to in-state tuition. If one is establishing residency for tuition purposes on his/her own, he/she must be either 22 years of age for a full-year or emancipated at the beginning of the one-year waiting period. Emancipation means completely self-supporting and financially independent. Marriage is an automatic act of emancipation. The one-year rule applies to everyone without exception.

A domicile is a person's true, fixed, and permanent home. Having a domicile in Colorado involves more than mere physical presence or 'residence' in the state. A person may have several places of residence but can have only one true domicile at any given time."

Some steps you can take that help to show that you are domiciled in Colorado include registering to vote, registering your car in Colorado, and getting a Colorado driver's license. We strongly encourage you to take all of these steps as soon as possible.

2.3 Selecting an Advisor

Initially, your assigned advisor will be the Graduate Coordinator. We usually have group advising sessions for all Ph.D. and Master's en route students each semester. These sessions give you a chance to meet with several faculty on the school's Graduate Committee to discuss your program.

As you progress through the program, you will want to select a research advisor whose research interests are in line with your intended research area. A student can change from their initial advisor to the research advisor by asking the School secretary to submit a New Advisor Assignment Form to the Graduate School. Your research advisor is very important—you should select one as soon as possible during your second year. See Section 5.1 below for additional comments concerning the final composition of the research committee.

3 IN THE FIRST YEAR OF THE PROGRAM

3.1 The Plan of Study

You are required to develop a Plan of Study, which describes how you will fulfill the requirements of the degree program as stated in the UNC catalog and reprinted below in Section 3.2. Ideally, the Plan of Study should be completed near the end of the first semester or during the second semester of study. It must be filed before comprehensive examinations can be taken. Revisions to the Plan of Study can be made subsequent to the initial filing, subject to the approval of the graduate coordinator and the student's advisor. We suggest that you look at the schedule of course offerings and lay out a program that enables you to accomplish your plan of study in the most efficient manner, observing all prerequisites. See Section 3.3.1 for the rotation of when classes are offered, and for sample four year plans of study.

Entering students normally take MED 610, MED 654, SRM 502, and a Mathematics course in their first semester. MED 710 is normally taken in the second semester. The remaining details of the composition of the second-semester coursework are best worked out while preparing the Plan of Study.

Master's en route students must file two independent and non-overlapping plans of study, one for each degree.

3.2 UNC Catalog Program Requirements

The UNC Catalog lists the following Program Requirements:

Content Core — 27 semester hours

A. Required Courses — 12 hours

- MATH 709 Abstract Algebra I (3)
- MATH 723 Abstract Algebra II (3)
- MATH 732 Complex Variables (3)
- MATH 735 Real Analysis (3)

B. Minimum of 15 hours chosen from the following courses:

- MATH 622 Directed Studies (1–4)
- MATH 700 Advanced Seminar (2)
- MATH 727 Representation Theory (3)
- MATH 728 Topics in Discrete Mathematics (3)
- MATH 733 Geometric Analysis (3)

MATH 736 Real Analysis II (3)
MATH 744 Differential Geometry (3)
MATH 764 Difference Equations and Chaos (3)
MATH 778 Mathematical Logic (3)
MATH 791 Number Theory (3)
MATH 795 Special Topics (3)

At most, two courses may be included from the following: (The two courses may both come from Category I but at most one course can be from Category II.)

Category I

MATH 525 Linear Algebra I (3)
MATH 532 Basic Analysis II (4)
MATH 540 Introduction to Topology (3)

Category II

MATH 528 Discrete Mathematics (3)
MATH 529 Mathematical Problem Solving (3)
MATH 531 Basic Analysis I (4)
MATH 543 Modern Geometry (3)
MATH 560 Introductory Complex Variables (3)

Research Core — 12 hours

MED 610 Survey of Research in Mathematics Education (3)
MED 700 Cognitive Processes in Mathematics (3)
MED 701 Educational Mathematics Research (3)
MED 702 Qualitative Research in Mathematics Education (3)

Educational Core — 10 hours (minimum)

A. Required Courses (4 hours)

MED 703 Teaching and Learning K-12 Mathematics (3)
MED 710 Seminar in Post-Secondary Mathematics Teaching (1)

B. Elective Courses (6 hours) (Advisor must approve courses)

MED 622 Directed Studies (1–3)
MED 630 Technology in Mathematics Education (2)
MED 673 Teaching and Learning Mathematics on the Elementary Level (3)
MED 674 Teaching and Learning Mathematics on the Secondary Level (3)
MED 675 Teaching and Learning Mathematics on the Post-Secondary Level (3)
MED 678 Special Topics (2-3)

MED 750 History and Philosophy of Mathematics Education (3)

Research Proposal/Dissertation — 16 hours

MATH 797 Doctoral Proposal Research (1–4) (Take 4 hours)

MATH 799 Doctoral Dissertation (1–12) (Take 12 hours)

Additional Electives — 6 hours

Electives in this category can include any approved 600 or 700 level courses or any two approved additional 500 level courses. Courses taken for the two research tools may be counted for these electives. A student must complete research tool "option A" and may select any one of the remaining four options.

Research Tools

A. Applied Statistics and Research Methods

SRM 502 Applied Statistics (4) (or approved equivalent)

MED 701 Educational Mathematics Research (3)

SRM 608 Experimental Design (3) (or approved equivalent)

or

SRM 610 Statistical Methods III (3)

Select One Additional Tool (0–3 hours)

B. Qualitative Research Methods. Student's doctoral committee will approve a combination of coursework (including at least SRM 680 and MED 702) and experience (evaluated by the committee) to appropriately support the student's proposed dissertation research.

C. Collateral Field. Contact the graduate coordinator for a detailed list of approved courses in cognition, instruction, measurement and evaluation, psychology and human development and curricula.

D. Computer Science. Student's doctoral committee will approve and evaluate a combination of advanced computer experience, proficiency and/or coursework only if relevant to the proposed dissertation research.

E. Foreign Language. Student's doctoral committee will approve and evaluate a combination of foreign language experience, proficiency and/or coursework only if relevant to the proposed dissertation research.

Note(s): Electives must have the approval of the student's advisor and doctoral committee.

MED 710 is normally taken the second semester of your program.

Students in this program must pass written comprehensive exams in mathematics and mathematics education followed by an oral comprehensive exam over their entire program. A document describing examination procedures may be obtained from the program office or the program website.

A student in this program is required to write a scholarly dissertation. Dissertation topics may range from mathematics with pedagogical applications to topics in educational mathematics such as cognitive processes, educational reform and instructional issues.

3.2.1 Commentary on the catalog Description

The purpose of these courses is to prepare you to do mathematics education research (write your dissertation).

MED 610 is the introductory course to the PhD in Educational Mathematics. It serves as an introduction to the literature and should be taken in your first semester. It is a prerequisite for all other MED courses except MED 673 and MED 654. The only MED course with an additional prerequisite is MED 701, which also has SRM 502 as a prerequisite.

The 6 hours of electives in mathematics education can be selected from the following: MED 622, MED 630, MED 673, MED 674, MED 675, MED 678, MED 750, or, if you intend to use a collateral field to complete your second research tool requirement, 6 hours in education and educational psychology courses approved by your advisor and doctoral committee.

Most Educational Psychology courses above the 600 level will also be accepted as mathematics education electives. These courses would partially fulfill the 6 hours of mathematics education electives.

Any other deviations or exemptions from the list of accepted courses must be approved by the Graduate Committee and fowarded to the Graduate School for approval. If you add up the hours for the content core (27), the educational core (10), the research core (12) and the dissertation (16), then you have accounted for 65 of the 71 hours needed to complete the program. That leaves you with 6 hours of electives which can be taken from any approved 600 or 700 level course or any two approved 500 level courses. While this is technically correct, you still have to satisfy the graduate school research tool requirements. In order to keep the hours in your program near the 71 required, it is prudent that you use your electives to fulfill these requirements.

The Graduate School research tool requirements can be met with few additional hours added to the minimum 71. The statistics courses in research tool A, SRM 502 and SRM 608/10, can be used as additional electives. These classes are then part of the 71 minimum hours required for the program.

Most commonly, students choose research tool B for their second research

tool. This choice usually only requires taking one extra course, SRM 680, and is strongly recommended for students planning to do qualitative dissertation research. However, some students may want to consider a collateral field for their second research tool. One good possibility is the collateral field in cognition. To complete a collateral field requires 9 hours of course work, but 6 of the nine hours could be counted towards mathematics education electives.

Students wishing to use Computer Proficiency as their second Research Tool will be asked to submit to the the program coordinator a written description of their computer background, summarizing relevant computer projects they have completed within the workplace or in academic courses. Normally, Computer Proficiency can only be used as a second research tool when it is relevant in some way to the student's research plans.

3.2.2 Additional requirements and restrictions

1. Appropriate coursework can be transfered into the program, as long as
   (a) it is from an accredited institution that grants graduate degrees;
   (b) it has not been counted towards a previous degree;
   (c) it was awarded a grade of at least a B; and
   (d) it doesn't constitute more than 31 of the required 71 credit hours in the program.
2. To transfer in credit hours, a student must complete a "Petition to Count Work in a Degree Program," available on the Graduate School website.
3. A maximum of 9 semester hours of courses numbered 508, 513 or 622 may be used in a doctoral program.
4. The time limit for completing this degree program is eight calendar years, commencing from the first coursework applied to the program. A transfer course taken earlier at a prior institution does trigger the eight-year clock.

3.2.3 Exemptions

Any deviations from the catalog requirements above must be formally requested by filing a Graduate Student Petition for Exception with the Graduate School. This form can be found on the Graduate School website. The student's advisor and the graduate coordinator must approve such exemptions before the formal request is transmitted to the Graduate School. Requests for course substitutions not previously approved as electives must be examined by the Graduate Committee.

3.3 Scheduling

A student making normal progress typically takes 9–10 credit hours of required classes per semester. The program requirements total 71 credit hours, and $8 \times 9 = 72$, so such a student can complete these requirements in 8 semesters—4 years. Students who transfer in credits and/or take summer classes may be able to finish sooner, while students who take additional classes may take longer. Even having taken summer courses, most students will need to continue taking math elective courses while working on their dissertations in order to finish in 4 years.

Regardless of your plans, timing is critical. You must plan your program carefully to ensure that classes will be offered when you need them. Get a copy of future course offerings and sit down with your advisor to lay out a program. Check the prerequisites for courses carefully. MED 610 is a prerequisite for most other MED courses. MED 701 has an additional prerequisite, SRM 502. It is essential to take MED 610 and SRM 502 as soon as possible.

Tuition waivers that are received for being a TA normally only cover 10 credit hours maximum per semester. However, if you need to take 11 credit hours in a semester, it is sometimes possible to get the Graduate School to grant an exception and pay for the 11th credit hour as well. If you are planning to take 11 credit hours in a semester, you should let the graduate coordinator know as soon as possible, so that he or she can ask the Graduate School if they are willing to grant such an exception.

3.3.1 Sample Schedule

Sample schedules, starting in odd and even years, are given in Tables 2 and 3. Most students will also take MED 654 (course coordination) in many

Semester	MED	Math	Master's	SRM
Odd Fall	Med 610	Math 735	Math 525	SRM 502
		Topics		SRM 680
				SRM 610
Even Spring	MED 702	Math 732	Math 560	SRM 608
	MED Topics		Math 523	SRM 680
Even Summer			Math 534	SRM 610
				SRM 680
Even Fall	Med 610	Math 709	Math 531	SRM 502
	Med 703	Topics		SRM 680
				SRM 610
Odd Spring	Med 700	Math 723	Math 540	SRM 608
	Med 701	Topics	Math 532	SRM 680
Odd Summer			Math 543	SRM 610
				SRM 680

Table 1: When courses are normally offered

semesters. Table 1 lists when courses are normally offered. For the most part, Ph.D. core courses are offered once every 4 semesters.

Year 1	Fall	MED 610
		Math 735
		SRM 502
	Spring	MED 702
		Math 732
		MED 710
		MED Elective
	Summer	SRM 680 or 610 or Master's math course
Year 2	Fall	MED 703
		Math 709
		Math Elective
	Spring	MED 700
		Math 723
		MED 701
	Summer	Comps, SRM 680 or 610 or Master's math course
Year 3	Fall	Math Elective
		SRM 610 or 680, if needed
		MED 797 (Proposal hours)
	Spring	MED 674 or MED Elective
		Proposal or Dissertation hours
	Summer	MED 799 (Dissertation hours)
Year 4	Fall	Math Elective
		MED 799 (Dissertation hours)
	Spring	Math Elective
		MED 799 (Dissertation hours)
	Summer	MED 799 (Dissertation hours)

Table 2: Sample Schedule, starting in an odd numbered year

Year 1	Fall	MED 610
		Math 709
		SRM 502
	Spring	MED 700
		Math 723
		MED 710
		MED 701
	Summer	SRM 680 or 610 or Master's math course
Year 2	Fall	SRM 610
		Math 735
		Math Elective
	Spring	MED 702
		Math 732
		MED Elective
	Summer	Comps, SRM 680 or 610 or Master's math course
Year 3	Fall	Math Elective
		SRM 610 or 680, if needed
		MED 703
		MED 797 (Proposal hours)
	Spring	MED 674 or MED Elective
		Proposal or Dissertation hours
		Math 525, if needed
	Summer	MED 799 (Dissertation hours)
Year 4	Fall	Math Elective
		MED 799 (Dissertation hours)
	Spring	MED Elective
		MED 799 (Dissertation hours)
	Summer	MED 799 (Dissertation hours)

Table 3: Sample Schedule, starting in an even numbered year

4 YEARLY ACTIVITIES

4.1 Program Progress Review

The graduate coordinator will evaluate and provide an annual progress report for each doctoral student until the student passes the oral comprehensive examination. This report will provide specific feedback to students regarding demonstrated strengths and recommendations for improvement. Where changes or improvements are expected in performance or professional conduct, well-defined time frames and deadlines will be included in the student's program progress report. Copies of the progress report will be sent to the Graduate School by the end of the Spring Semester each academic year for all doctoral students enrolled during the previous calendar year who have not yet passed oral comps. Requests to close or terminate a student's program will be initiated by the School of Mathematical Sciences through the Graduate School.

TA's will be evaluated in 3 areas: their teaching, their performance in their classes and their progress in their program.

Evaluation of teaching. Students should be observed at least once, preferably twice, a semester. This will most often be done by the coordinators of the courses the students are teaching. Student evaluations will also be used to assess how TA's are teaching. TA's should conduct self-assessments and discuss them with their course coordinator.

Evaluation of performance in the classes the TA's are taking. This is normally done by the professors teaching those classes, and is also indicated by the grades the students earn in these classes.

Evaluation of progress in program. The following list outlines expected progress in the program, assuming that a student will take 4 years to complete a Ph.D. If a student fails to complete an item on the list at the proposed time, his/her situation should be considered to determine if that failure indicates lack of degree progress or if there are extenuating circumstances.

Time	Action
End of 1st semester	Create a plan of study.
By end of 3rd, preferably by end of 2nd semester	Know what math comps you will take.
By end of 4th, preferably by end of 3rd semester	Pick an advisor.
Between 4th and 5th , but no later than before 6th	Take comps and orals.
By end of 6th	Defend dissertation proposal.
During 7th	Evaluate to see if ready to defend in 8th semester, or end of summer at latest.

In addition, students are also expected to do the following:

- attend the school seminar on a regular basis;
- become involved in research projects before beginning their dissertations;
- attend and present at conferences.

Being part of a Ph.D. program is more than taking classes. You are preparing to be a professional and want to take advantage of the opportunity to begin that process. Toward that goal, we encourage you to go to conferences (e.g. SIGMAA on RUME, AERA, PME, CCTM, MAA, AMS), prepare your vita and update it regularly, write papers for publication, attend the school seminars and colloquia, and give talks (at UNC or outside UNC). While this is a long list and you cannot be expected to do all of this in any given year, do commit to doing a variety of things (well). Students who are planning to go to a conference should notify the School's administrative assistant and fill out appropriate paperwork before they go.

Students will submit a report on their progress with respect to the above list each spring along with any supporting evidence they would like to include. Students are encouraged to collect such evidence throughout the year and to keep it organized into a portfolio. Such a portfolio is likely to be extremely helpful later on as you are applying for jobs. Students who have passed oral comprehensive exams are still required to submit an annual report each year.

The Graduate Coordinator will collect all of the above information from students and faculty members and use it to produce written evaluations.

4.2 Summer Support

The School of Mathematical Sciences tries to provide some support during the summer for Ph.D. students, including Masters en route students, to assist faculty members with their research projects. When available, this support is in the form of a graduate research assistantship supervised by a faculty member in the School of Mathematical Sciences.

The School of Mathematical Sciences will assist the students in finding appropriate activities. In particular, we will provide a list of faculty research projects that are possible projects for the summer. However, it is the student's responsibility to request supervision by a faculty member for the summer activities, and applications for summer support should be submitted through the supervising faculty member.

Support for the summer is provided on a total funds basis; the total will be allotted to students in shares. The amount per share will depend on the total funds available and the number of shares granted. Students may apply for up to two shares of support. For a share of support we expect approximately 60 hours of work, distributed over the summer. Each spring, students will apply for support, describing their intended activities and who they propose will supervise their activities.

Students who teach a 3-credit course during a 6-week summer session are considered to be employed full-time and will not receive support during that session, but may still request one share of additional support. Students may request part shares if they will only be working on program activities part-time during the summer. Master's en route to Ph.D. students are also eligible to apply.

Support will be awarded by the Graduate Committee in consultation with the School Director. Decisions about levels of support may be influenced by the following:

1. The student's previous progress in the program.

2. The student's satisfactory use of previous summer support.

3. Balancing research assistance among faculty members.

If students make changes in their summer plans after submitting their applications, they should inform the Graduate Coordinator.

Expectations for students receiving summer support:

- Each student will keep a log documenting the time spent working on their project.
- Each student will write a brief final report at the end of the summer explaining what activities they were engaged in and how those activities supported progress in their program. Supporting documents and /or work products should be included. The report must be signed by the faculty supervisor.

The process of awarding summer support will roughly follow the following timeline:

Late Fall The graduate coordinator solicits research projects from faculty members

February 1 Deadline for faculty members to give research projects to graduate coordinator

February 10 Graduate coordinator distributes list of research projects approved by Ph.D. committee to graduate students

February 20 Deadline for graduate students to apply for summer support through their proposed faculty advisor

March 15 Graduate students notified of summer support awards.

4.3 UNC School of Mathematical Sciences Annual Award for Teaching Excellence by a Graduate Student

Every year, the School of Mathematical Sciences recognizes a graduate teaching assistant for excellent teaching through our teaching award. The winner is recognized at the annual graduate student induction ceremony, and their name is added to the plaque in the main mathematics office.

Purpose: To recognize, encourage and document excellent instruction by teaching assistants.

Who is eligible: Graduate students in the Educational Mathematics Ph.D. program who have been teaching assistants in the School of Mathematical Sciences for at least three semesters at UNC. Previous recipients cannot be nominated a second time.

Who decides: The executive committee of the graduate committee, in consultation with the School Director.

Important dates: (These may change slightly from year to year.)

- Applications from nominated students are due by October 1.
- Committee decides by October 15.
- Winner is announced at Graduate Student Induction Ceremony.

Nomination process: Two to four eligible students will be nominated by the committee and asked to submit an application. The nominations will be informed by:

- Graduate students' annual progress reviews
- Student evaluations
- Information from Director
- Information from course coordinators

Application materials to be submitted by the nominees:

- Teaching Statement of no more than 4 pages
- Student evaluations from a representative sample of classes, all evaluations included from the classes chosen
- Current Vita
- Up to 10 pages of supporting documentation such as sample syllabi, class activities, student work, letters about teaching, observation forms, items from a teaching portfolio.

Indicators/Criteria for selection:

- Ability to develop students' appreciation and understanding of mathematics
- Creative use or development of materials
- Success in helping students master material
- Improvement of teaching skills over time
- Student evaluation indicators

- Activity in the coordination seminars
- Being recognized by peers as a teaching mentor
- Teaching effectiveness that can be documented
- Having had an influence in their teaching beyond their own institution through research, publications or presentations
- Participation in the faculty mentoring program
- Initiative in taking on new teaching assignments
- Fostering curiosity and generating excitement about mathematics in their students.
- Teaching a variety of courses

5 THE SECOND YEAR IN THE PROGRAM

5.1 Choosing a Doctoral Committee

A student's doctoral committee must be appointed before the student takes the written comprehensive examination. The committee must be appointed no later than the end of the semester prior to the scheduled written comprehensive examination. This committee, chaired by the student's research advisor, shall guide the student through the research and dissertation process. The Graduate School requires that the chair of this committee be a member of the Graduate Faculty with the Doctoral Research Endorsement. Check with the Graduate School or within the department for a list of eligible faculty. Students should pick their research advisor first, and then consult with their advisor in picking the other members of their committee.

The committee must have at least four members, but may have more. Of these, at least two must be members of the School of Mathematical Sciences, and one must be an outside faculty representative, appointed by the Graduate School. All members of the committee must be members of the Graduate Faculty. It is customary for the student, in consultation with their advisor, to request the outside faculty representative.

The committee is appointed after the student and advisor complete and submit a Request for Appointment of Doctoral Committee, available on the Graduate School website.

5.2 Requesting Written and Oral Comprehensive Exams

All doctoral students must take and pass a written comprehensive examination prior to the oral comprehensive examination. The date of the oral exam can be scheduled either in the same semester as the written exam, or in a subsequent semester. Master's en route students must complete all requirements for the M.A. before taking written Ph.D. comprehensive exams.

All students must submit a completed Written Comprehensive Request Form to the School administrative assistant, who will check the criteria below. Submit your request no later than two weeks prior to the scheduled examination.

Before a student can take the written comprehensive exams, the student must:

- have been granted regular admission to the degree program;
- have filed an approved Plan of Study;
- have completed 36 hours in the program (24 on campus);
- have maintained a GPA of at least 3.00 in the program;
- have received at least satisfactory program progress evaluations;
- had a doctoral committee appointed;
- obtained approval to take the written exam from the graduate coordinator; and
- notified the graduate coordinator which mathematics sequence they are choosing to be tested on (if they are taking the comprehensive exam under the old requirements).

In order to schedule the oral comprehensive exam, a student must submit a Request to Schedule Doctoral Examinations no later than 14 calendar days before the exam date.

5.3 Written Comprehensive Examinations

The comprehensive examination consists of three portions: algebra, analysis, and mathematics education. The algebra portion of the comprehensive examination will consist of a three-hour exam over the Math 709/723 sequence. The analysis portion of the comprehensive examination will consist of a three-hour exam over the MATH 735/732 sequence. The mathematics education portion will consist of a six-hour examination over the material in the research core (MED 610, MED 700, MED 701, MED 702) and a list of required readings. If a student is prepared to take some portions of the exam but not others, the three portions may be taken during different summers. The oral comprehensive examination will be given upon successful completion of the written examination and will cover the entire program of the candidate.

See Appendices C and D for the School of Mathematical Sciences standards for mathematics and mathematics education comprehensive exams. A set of copies of old exams and study materials maintained by the graduate

students is available in the School of Mathematical Sciences office for use in studying for comps.

5.3.1 Timing of Comprehensive Examinations

Comprehensive examinations are offered once per year, during the summer, and are scheduled by the graduate coordinator in consultation with the Ph.D. committee, the students involved and the examination writers/graders. Normally, comprehensive exams will be scheduled in August, two weeks before the beginning of the fall semester. Students who fail comprehensive examinations must wait to retake them at the next regularly scheduled time.

5.3.2 Time for the Examinations

The analysis examination will be a three-hour examination given on one day. The algebra examination will also be a three-hour examination given on another day. The Mathematics Education examination will be given in two three-hour parts on two separate days. Thus, the total number of exam days will be four. Each part of an examination is designed to be answered in three hours. This is the normal examination period.

Students who are not native speakers of English can petition for more time to complete the exam and may receive an additional hour on each part. Students must submit their requests in writing to the graduate coordinator at the time they request comprehensive exams.

In addition to the above, any accommodations approved by DSS (Disability Support Services) will be made.

5.3.3 Grading Comprehensive Examinations

When the comprehensive exam is graded only two outcomes may be reported to the Graduate School; these outcomes are Pass or Fail. A student's performance on the exam leads to one of these outcomes.

After the examination is taken, the mathematics education portion of the examination is graded by the mathematics education comprehensive examination committee, the algebra portion of the exam is graded by the algebra comprehensive examination committee, and the analysis portion of the exam is graded by the analysis comprehensive examination committee.

Each of these committees assigns a grade for their portion of the exam. This will be one of three general possibilities. The student may:

Pass. The student fully met the expectations and passed this portion of the examination.

Pass with conditions. The student came very close to meeting the expectations. The student is given conditions and a time frame for meeting them. The time frame will normally be less than two months. The conditions can involve written work, oral presentations, or retaking a part of the exam focused on a particular topic, or a combination of these possibilities.

Fail. The student failed the examination.

After all of the examination committees have graded an exam, their results will be reported to the School graduate committee, which will assign an overall grade to the exam and report it to the student. A student will be considered to have passed the comprehensive written examination if and only if they have passed all three portions of the exam.

If a pass with conditions is received, then the report to the graduate school is delayed until the conditions have been resolved. If the given conditions are met within the given time frame, a pass is then reported; if they are not met, a fail is reported.

If a fail is reported to the Graduate School, students may not re-take comprehensive examinations during the same semester that they failed them.

If a student passes some portion of the exam but fails other portions, when they retake the exam, they will only be required to retake the portions they failed.

It is a policy of the graduate school that written comprehensive examinations may only be retaken once. Failure of a retake will result in the termination of the student's degree program.

If the three portions of the exam are not all taken during the same summer, the following policies will apply. A passing grade will not be reported to the graduate school until all three portions of the the exam have been passed. If any portion of the exam is failed, a failing grade will be immediately reported to the graduate school. A second failing grade will be reported to the graduate school if and when any individual portion of the exam has been failed twice.

5.3.4 Reporting on Written Comprehensive Exams

After the written comprehensive examination has been taken (and before the oral comprehensive examination can be scheduled), the graduate coordinator must submit the results of the written examination to the Graduate School.

School of Mathematical Sciences policy is to have the graduate coordinator inform students of the written comprehensive results after the whole exam has been evaluated. Students should refrain from asking individual faculty members for results.

Once students have passed the comprehensive examination, they may schedule oral exams which will be administered by their committee. All future work in their program will be evaluated by their committee and their advisor(s).

5.4 Oral Comprehensive Exams

After passing the written comprehensive examination, every doctoral student must take and pass an oral comprehensive examination. Oral examinations are officially run by the University, rather than the School of Mathematical Sciences. They must be scheduled with the graduate school two weeks in advance, so that they can be publicized to the whole University. Any university faculty member is welcome to attend any oral comprehensive exam, and has the right to ask questions of the student after the committee members finish their questioning. Other graduate students may also attend with permission from the chairperson of the committee.

The oral comprehensive exam has several purposes. Some of these purposes are:

- To demonstrate the ability to intelligently carry on wide-ranging discussions in mathematics and mathematics education, as will be expected of you in job interviews and as a member of the academic community;
- To demonstrate comprehensive knowledge of mathematics and mathematics education beyond the core courses required for the written comprehensive exams;
- To demonstrate sufficient content preparation to proceed to working on your dissertation and other independent research.

To meet these goals, your committee members may choose to ask you several different kinds of questions. Some possibilities are:

1. Questions about the subjects covered in your written comprehensive exams. These may include questions about your responses on the written exam, and/or questions about things that were not included on the written exam.
2. Questions about other subjects that you have studied in your program that were not included on the written comprehensive exams.
3. Questions related to the area in which you are planning to do dissertation research and/or about your planned research.
4. Questions that explore the connections between topics that you have studied in different classes.
5. Questions that are designed to allow you to demonstrate process skills such as the ability to prove theorems, communicate big picture ideas, perform analysis of ideas, *etc.*

Every oral comprehensive exam is personalized to the student taking it. Since faculty members may ask any questions that they think are appropriate, oral exams will differ among students. Thus, it is impossible to predict the questions that will be asked during a given student's oral exam. However, students are strongly encouraged to discuss the likely contents of their exam with their committee members in advance, and especially with the chairperson of their committee. Committee members are usually willing to give students an idea of what areas they should focus on in preparing for the exam.

Students are responsible for arranging the date, time and place of the oral examination with all committee members. After all arrangements are made, the student notifies the Graduate School by forwarding a signed and completed Request to Schedule a Doctoral Examination form.

In order for the Graduate School to approve a request for the student to take the examination, the following conditions must be met:

- The committee members and faculty representative must be the same as those approved by the Graduate School.
- The written comprehensive examination results must have been received and recorded by the Graduate School prior to requesting to schedule the oral comprehensive examinations.
- The Request to Schedule a Doctoral Examination must be turned in to the Graduate School at least two weeks (14 calendar days) before the requested date of the examination to allow for any problems to be addressed.

All committee members and the faculty representative must be present at the examination unless a substitution has been officially approved by the graduate school. The student's performance on the examination will be evaluated as:

1. pass;
2. conditional pass (conditions for passing will be recorded on the Results of the Oral Comprehensive Examination before it is turned in to the Graduate School);
3. fail, with option to retake permitted; or
4. fail, retake not permitted

At least three-fourths of the committee members must agree on the final evaluation.

6 THE THIRD YEAR AND BEYOND

6.1 Dissertation Proposal

Upon completing the comprehensive exams successfully, the student should register for Dissertation Proposal hours (Math 797) and also begin developing a dissertation proposal with the guidance of his or her advisor and doctoral research committee. The Graduate School currently allows Math 797 to be taken during the same semester that the oral comprehensive examination is passed.

It is acceptable for students to register for proposal hours prior to completing written comprehensive exams, provided that the student has a duly constituted dissertation committee and the dissertation advisor approves.

When the research advisor believes the proposal is ready for defense, the advisor and student should schedule a time for a presentation to all members of the research committee. A copy of the proposal should be given to each member of the committee and a minimum of three weeks should given to each member of the committee to review and critique the proposal.

If all committee members sign the proposal, it is considered approved by the Graduate School. The student then submits the approved proposal to the Graduate School. A minimum of 4 credit hours of Math 797 must be earned before an approved proposal can be submitted to the Graduate School.

6.2 Admission to Doctoral Candidacy

Admission to doctoral candidacy is a formal step that must be accomplished before a student is allowed to register for Math 799. Moreover, no student can be graduated sooner than the semester after he or she is admitted to candidacy.

To be eligible for admission to candidacy in this program, a student must:

- have completed MED 701;
- have earned at least 39 semester hours of credit;
- have a cumulative G.P.A. of at least 3.00;
- have passed the written and oral comprehensive exams;
- have submitted an approved proposal to the Graduate School;

- have registered for 4 hours of Math 797; and
- have met the research tools requirements or be working on a collateral field in lieu of the second research tool.

Admission to candidacy is handled automatically by the Graduate School after the approved dissertation proposal reaches them and no further formal application is required. Once a student has been admitted to candidacy, she or he must be continuously enrolled until the program is completed. Continuous enrollment does not preclude being located off-campus, but special fees may then apply.

6.3 The Dissertation

A student prepares a dissertation in close collaboration with the research advisor and research committee and in conformance with the approved proposal. The official style (for citations, bibliography, and so on) for the School of Mathematical Sciences is the American Psychological Association style. The School owns a copy of the *Publications Manual of the American Psychological Association* and the graduate student representative to the Graduate Committee is the official "keeper of the manual." Contact the Graduate School for the most current edition; it is also available in Michener Library and from the UC Bookstore. In addition, dissertations must meet all of the style requirements of the University *Thesis and Dissertation Manual*, available from the graduate school web page.

6.4 The Dissertation Defense

When the student and advisor and committee feel the dissertation is in final form, the student will submit a copy of the final draft to the Graduate School and request a defense date. The defense date must be no sooner than two weeks after the request is made. The defense must occur at least five weeks (35 calendar days) before the anticipated graduation date. The dissertation committee will evaluate the dissertation and the student's defense of it and assign a pass, a pass with conditions, or a failure.

The evaluation of the dissertation and its defense is communicated to the Graduate School on the Report of Defense of Dissertation form.

6.5 Graduation

Formal application for graduation must be filed with the Graduate School at least 30 calendar days before the beginning of the semester during which the student plans to graduate.

The advisor gets to hood the successful candidate!

A Additional Policies

A.1 Graduate Student Representation on the School Graduate Committee

The following policy has been approved by the Graduate Committee relative to graduate student representation:

1. All graduate students who have passed their comps are eligible.
2. A representative shall be selected by the graduate student body and the name presented to the School Director for appointment.
3. Term to be one academic year, with repetition allowed.
4. Student Representative will be a non-voting member of the Graduate Committee.

A.2 Guidelines for the awarding of teaching and graduate assistantships

Students in the Educational Mathematics Ph.D. program who are making satisfactory progress (as indicated by program progress reviews) and are satisfactorily performing their duties may normally count on four years of support from School funds as a teaching or graduate assistant. Students who wish an additional year of support may receive it, at the discretion of the graduate committee, the graduate coordinator, and the school director. In making this decision, we will consider evidence of degree progress (*e.g.*, completion of comprehensive exams, selection of dissertation advisor and topic, completion of proposal, *etc.*) as the primary factor in awarding additional support. Other factors may include School budgeting and needs, evidence of good teaching, or other factors. Support beyond the fifth year will probably be awarded only in exceptional cases.

The purpose of teaching assistantships (and the source for their funds) is to support the Ph.D. students. Full-time Master's degree students may be supported on a semester-by-semester basis, depending on the availability of funds and at the discretion of the School Director and the graduate coordinator. A student in a Master's degree program will be supported for a maximum of 4 semesters except under exceptional circumstances.

A student completing a Master's degree and entering the doctoral program and a transfer student beginning the doctoral program are to be considered as "new" doctoral students with respect to the above policies. This means that students in the Master's en route program may be supported as TAs both as Master's students and then as Ph.D. students, for a total of 6–7 years of potential support.

Teaching assistants who are teaching MATH 120, 124, 181, or 182 are expected to regularly attend course coorindation meetings and to spend one of their office hours each week in the Mathematics Tutoring Lab. Normally, students receive credit on their transcripts for these activities by taking MED 654.

B Master's en route to the Ph.D. Program

Students who are admitted to the Ph.D. program in Educational Mathematics and who wish to also earn the M.A. in Mathematics, Liberal Arts emphasis, may do so en route to their Ph.D. They must complete all the requirements for the M.A. in addition to the requirements required for the Ph.D. Students must be conferred with the M.A. degree prior to admission to doctoral candidacy. It is the policy of the School of Mathematical Sciences that students complete the requirements for the M.A. before taking written Ph.D. comprehensive exams.

Students who enter the doctoral program with only a Bachelor's degree are required complete the M.A. in mathematics, Liberal Arts Emphasis, as part of their degree. In addition, it may make sense for some students who have a Master's degree in a different field to take some prerequisite mathematics; in some cases they may need to take enough courses that they could fulfill the requirements for an M.A.

Each student must file two non-duplicative plans of study with the Graduate School that specify the courses taken for each degree; no course used for the M.A. can be used for the Ph.D. or vice versa. The School of Mathematical Sciences does not require many specific courses due to the fact that different people may need to take different mathematics courses to prepare them for Ph.D. work. Courses for this program will be selected by the student's advisor and approved by the Graduate Coordinator. Each student must complete 30 hours toward the Master's degree in addition to 71 hours toward the Ph.D.

Tables 4 and 5 show sample plans of study for Master's en route students starting in even and odd years. "M" denotes a Master's level course, "PhD" denotes a PhD level course, and "RT" denotes a course taken for one of the Ph.D. level research tools. Note that an unlimited number Ph.D. level courses may be counted in the Master's degree, but at most two Master's level courses may be counted in the Ph.D. Also note that these sample plans of study are designed for students who want to take as many courses as possible at the Master's level before taking Ph.D. level classes. Many Master's en route students choose to take more Ph.D. level courses earlier in their programs if their backgrounds are strong enough. This can make it possible for a Master's en route student to devise a plan of study that will allow them to take their comprehensive exams during their third summer, rather than their fourth summer. This illustrates one advantage to pursuing the Master's en route

Year 1	Fall	MED 610	M
		Math 531	M
		SRM 502 (4)	RT
	Spring	SRM 608 or MED 7xx	RT or PhD
		Math 540	M
		MED 710 (1)	PhD
		Math 532	M
	Summer	possible M.A. Teaching Emphasis math courses	M
Year 2	Fall	Math 525	M
		SRM 680	M
		MED 5xx or Math 7xx	M or PhD
	Spring	MED 673	PhD
		MED 599 or Math 599	M
		Math 560	M
	Summer	possible M.A. Teaching Emphasis math courses	M

Table 4: Sample Master's en route Schedule, starting in an even numbered year

rather than completing the Master's degree first and then the Ph.D., which is that students can take some of the specific required courses for the Ph.D. in the course of obtaining the M.A. This flexibility can assist the student in completing course requirements and their dissertation project efficiently.

The following is the official catalog description of the M.A. in Mathematics, Liberal Arts Emphasis:

Required Emphasis Credits — 18 hours

MATH 525 Linear Algebra I (3)
MATH 531 Basic Analysis I (3)
MATH 532 Basic Analysis II (3)
MATH 540 Introduction to Topology (3)
MATH 560 Introductory Complex Variables (3)
MED 610 Survey of Research in Mathematics Education (3)

Required Elective Credits — 12 hours

Electives must be graduate level (500 or above) MATH, MED, or SRM courses, and must be approved by the student's advisor. At most 3 of the required elective credits can be from Math 599 or MED 599.

Comprehensive Examinations A student may select any of the following options to satisfy the comprehensive examination requirement. At least

Year 1	Fall	MED 610	M
		Math 525	M
		SRM 502 (4)	RT
	Spring	Math 560	M
		SRM 608 or MED 702	RT or PhD
		MED 710 (1)	PhD
		MED 673	PhD
	Summer	possible M.A. Teaching Emphasis math courses	M
Year 2	Fall	Math 531	M
		SRM 680	RT
		MED 5xx or MED 703	M or PhD
	Spring	Math 532	M
		Math 540	M
		MED 599 or Math 599	M
	Summer	possible M.A. Teaching Emphasis math courses	M

Table 5: Sample Master's en route Schedule, starting in an odd numbered year

two faculty members will be involved in judging whether or not the selected option has been completed satisfactorily.

- Option 1. Completion of an Action Research Project involving the selection of a problem related to the student's teaching, review of relevant literature, plan, analysis and discussion. A copy of this project must be filed with the School; in addition, the student must make a presentation of the project. Students who choose this option will normally take MED 599 or MATH 599 to support their work on the project.

- Option 2. Completion of a Masters Research Project involving the selection of a problem, review of relevant literature, plan, analysis and discussion. A copy of this project must be filed with the School; in addition, the student must make a presentation of the project. This project may be associated with a course the student is taking, as long as it is an independent research project of high enough quality and approved in advance by the graduate program coordinator.

- Option 3. A written comprehensive examination over at least 2 of the required courses agreed upon in advance with the graduate program

coordinator. Up to two hours of oral examination will be given upon successful completion of the written examination.

C Mathematics Comprehensive Exam Standards

The comprehensive examinations in mathematics are designed to assess students' understanding of the core subject material in Algebra and Analysis. Since graduates of the program are expected to be able to teach undergraduate mathematics courses and engage in educational research which is informed by a deep understanding of mathematics, the examinations are integral to the program. Students are required to take three-hour written comprehensive examinations over the Algebra and Analysis course sequences.

C.1 Standards for the comprehensive examination in mathematics

There are three standards for the mathematics comprehensive examination: Proof, Exposition and Content.

1. Proof. The student must show, by answering questions put forth on the comprehensive examination, their ability to prove theorems and propositions which are novel to them using the techniques of the field which are considered standard and common (this does not refer to memorized proofs of named theorems—such material is discussed in the content standard). These proofs may involve demonstrations that certain examples have given mathematical properties, that certain simple propositions hold or that certain truth relations obtain among various statements. Each comprehensive examination will have numerous opportunities to write such basic proofs in response to given questions.

2. Exposition. Each student is expected to show, in response to at least one examination item, that they can discuss important concepts of the field in clear and correct expository language, making appropriate use of standard examples, fundamental theorems, and typical representations. Each examination will contain at least one question to which an expository response is expected. (Oral examinations typically involve this sort of exposition more extensively.)

3. Content. Students are expected to respond to examination items in a way that will demonstrate their understanding of, familiarity with,

and ability to appropriately use (in solving problems) the content of the specific examination given. The content is divided into two kinds of material: Core material and peripheral material. Core material is that which all students who take the comprehensive examination are expected to have fully mastered, and which will be covered in some way in each course sequence upon which the comprehensive examinations are based. Peripheral material is relevant material which may appear on a comprehensive examination, and which may (at an instructor's discretion) be discussed in the required courses. All students are expected to be familiar with peripheral material, regardless of whether it was covered in any particular course. No more than 20% of the items on any examination will be focused on peripheral material.

C.2 Content Topics

- All students are to be familiar with so-called preliminary material involving functions, sets, logic, cardinality, relations, partitions, axioms for the integers, etc. which are typically found in introductory chapters (of say, Royden and Hungerford).

- All content topics listed below include definitions of the terms, ability to provide relevant examples and limiting counterexamples, and basic theorems involving the concepts, along with standard techniques for their use.

C.2.1 Algebra Content Topics

Core Material Topics: Groups, homomorphisms, isomorphisms, isomorphism theorems, cyclic and abelian groups, symmetric, alternating and dihedral groups, normality, quotient groups, group actions, center, centralizers and normalizers, conjugation, automorphisms, direct products. Rings, polynomials, prime and maximal ideals, units, integral domains, fields, field extensions, reducibility, Galois groups.

Peripheral Material Topics: Semigroups, monoids, indirect products, generators and relations, normal series, solvable groups, finitely generated abelian groups, applications of groups to complex analysis.

C.2.2 Real Analysis Content Topics

The overall purpose of the real analysis course is an understanding of the real numbers and their properties and an understanding of real-valued functions of a real variable, particularly with regard to integration, differentiation and convergence.

The content is organized around five major themes.

I. Topology and Properties of the Real Numbers

Students should understand the nature of open and closed sets in $\mathbb{R}$, understand the order properties of $\mathbb{R}$, and the concept of a sigma-algebra. They should be familiar with important kinds of subsets, such as $\mathbb{Z}, \mathbb{Q}, \mathbb{I}$, and Cantor sets. They should know about the extended reals and real-valued sequences, including lim sup and lim inf.

II. Real Functions and Sequences of Functions

Students should understand continuity and its relation to sets, and sequences of functions in relation to algebras of sets. The differences between pointwise and uniform convergence and other modes of convergence (L1-convergence, convergence in measure) are important here.

III. Lebesgue Measure and Integration

The important point here is to develop an understanding of how Lebesgue measure is created from outer measure, and how Lebesgue integration differs from Riemann integration, particularly with regard to which functions are integrable and which properties pass to limits.

IV. Differentiation Theory

Understanding the two versions of the Fundamental Theorem of Calculus in full generality requires the development of functions of bounded variation, absolute continuity and Lebesgue integration.

A full and rigorous development of each of these topics is not possible in one semester. Some choices will be made. Nevertheless, students should have a detailed understanding of topics I and II, and be able to provide numerous examples and do correct proofs in these contexts. For topics III and IV, what is important is knowledge of the basic definitions and theorems, an ability to exemplify them, and ability to explain the relationships among and importance of the various concepts, connecting the theorems and examples into a coherent conceptual whole.

C.2.3 Complex Analysis Content Topics

The core topics in complex analysis are

I. Algebraic, Geometric and Topological Properties of the Complex Plane

Arithmetic operations with complex numbers and their geometrical interpretations, triangle inequality, complex conjugation, modulus and argument, De Moivre's Theorem, roots of unity, limits of sequences of complex numbers, limit points, open and closed balls, path-connected open sets in the plane.

II. Continuous Complex-valued functions $w = f(z)$

Limit notation, continuity and its geometrical interpretation; the extended complex plane as the Riemann sphere, limit theorems concerning sums, differences, products, and quotients of complex functions; polynomials, rational functions, mapping properties of linear-fractional transformations $w = (az + b)/(cz + d)$.

III. Power Series

Series in general, absolutely summable series, power series, the geometric series, Abel's theorem, ratio test, Hadamard's formula for radius of convergence, products of power series, term-wise differentiation and integration of power series, definitions of exponential and trig functions via power series.

IV. Differentiation Theory

The complex derivative, geometrical interpretations of complex differentiability, contrasting real and complex differentiability at a point, examples of non-differentiable functions, the Cauchy-Riemann equations, sufficient conditions for complex differentiability, complex differentiability of the exponential and trig functions.

V. Integration Theory

Contour integrals with continuous integrands, complex anti-derivatives and the fundamental theorem of integral calculus for complex contour integrals, the winding number integral, the Cauchy Integral Theorem (CIT), deformations of contours, the Cauchy Integral Formula and its

proof via the CIT, Taylor's theorem, Morera's theorem, Liouville's theorem and the proof of the fundamental theorem of algebra, the circular mean value property, maximum modulus principle, local behavior of an analytic function at a zero of finite order, identity theorems, locating roots via Rouche's theorem and the argument principle.

VI. Isolated singularities and residues

Laurent's theorem, classification of isolated singular points via Laurent's theorem, poles of finite order, meromorphic functions, the Casorati-Weierstrass theorem concerning essential singularities, the residue associated to a isolated singular point, the Cauchy residue theorem, evaluation of classical integrals via the residue theorem.

D MED Comprehensive Exam Principles and Standards

D.1 Standards and Principles

D.1.1 Principles

P1 Equity of ideas.

Each theory is subject to careful consideration, analysis, and evaluation.

P2 Equity of expectations.

Each person is entitled to expectations of excellence and ethicism for themselves, for others, and for the profession, separately and collectively.

P3 Equity of approaches.

Every research approach is open to examination of its merits and shortcomings.

D.1.2 Standards

S 1 General/Theory

1. Theoretical Framework
   (a) existing theoretical paradigms in mathematics education
   (b) developing theoretical perspectives
   (c) learning theories
   (d) aspects of educational psychology and educational philosophy in theoretical design
2. Research Design
   (a) existing research paradigms in mathematics education
   (b) addressing issues of equity and quality in designing research
   (c) use of both quantitative and qualitative methods in research design
3. Implications of theory for

(a) research design
(b) practice
(c) further theory building

S 2 Quantitative Research

1. Framework
   (a) appropriate research questions using quantitative measures
   (b) quantitatively measurable variables
   (c) effectively combining quantitative with qualitative research
2. Research methods
   (a) data collection instruments
   (b) testing reliability and validity
   (c) classes of research design
      i. experimental designs
      ii. criterion group designs
      iii. correlational designs
      iv. path analysis designs
      v. meta-analysis designs
   (d) data analysis
      i. descriptive statistics: means, standard deviations, percents, etc.
      ii. inferential statistics: t-tests, ANOVA, ANCOVA, correlations, multiple regression analysis, non-parametric analyses, MANOVA.
   (e) appropriateness of test(s) chosen
   (f) interpretation of results
3. Implications of quantitative research methods for
   (a) research design
   (b) practice
   (c) theory building

S 3 Qualitative Research

1. Framework

(a) appropriate research questions using qualitative measures
(b) qualitatively measurable variables
(c) effectively combining quantitative with qualitative research

2. Research methods
   (a) data collection techniques
      i. field notes
      ii. video/audio tape
      iii. interview
      iv. free response writing
   (b) testing reliability and validity
   (c) classes of research design
      i. quasi-experimental designs
      ii. experiential designs
      iii. case studies
      iv. subjective vs. objective designs
   (d) data analysis
      i. grounded theory and other coding techniques
      ii. representational coding: identifying cognition, meta-cognition, affect, and meta-affect.
   (e) appropriateness of method(s) chosen
   (f) interpretation of results
3. Implications of qualitative research methods for
   (a) research design
   (b) practice
   (c) theory building

S 4 Practice

1. Framework
   (a) appropriate contexts for research-to-practice transfer
   (b) learning theories in action: constructivism, etc.
2. Research methods
   (a) teaching experiment

(b) curricular extension
(c) extra-curricular extension
(d) intervention
(e) testing reliability and validity
(f) data analysis
(g) appropriateness of method(s) chosen
(h) interpretation of results

3. Implications of practice for
   (a) research design
   (b) practice
   (c) theory building

D.2 Examination Process

At least 12 weeks prior to the examination, the Mathematics Education Comprehensive Examination Committee (MECE) will provide a reading list of 5 to 7 articles/book chapters that will be available to the examinee during the exam and that will be referenced in the exam itself. The expectation is that no more than three of these items will be new to any examinee; most will be chosen from the readings for the courses MED 610, 700, 701 and 702. One copy of each item will be made available for re-copying in the School of Mathematical Sciences office.

Exam questions may include specific references to the reading list items. Exam questions will also ask students to draw on other reading they have done in textbooks as well as journals and other references. The rubric for the exam will include a statement to the effect that any student who uses only the reading list items in their comparisons and discussions will not pass the exam.

Upon completion of the exam, the MECE Committee members will receive copies of each examinee's work. Each committee member serves as both a primary and a secondary reader: as primary reader, the committee member responds directly to the answers given to questions she or he posed; as a secondary reader, the committee member provides a general assessment of the rest of the examination answers. These assessments are not anonymous. The committee has 2 to 3 weeks to complete their assessments. An assessment form for each member for each exam will be given to the school secretary.

At the end of the grading period, the MECE committee chair collects the assessment forms on which committee members have indicated pass or fail. The MECE Committee will meet, review the forms, and determine the grade for the exam. The examinee is then provided with comments and a pass, conditional pass wherein some portion(s) of the exam must be retaken, or no pass.