THE GRADUATE HANDBOOK

November 2003

Contents

1 INTRODUCTION

This handbook is written for all prospective and present graduate students in the Department of Mathematics. It is intended to supplement, but not replace or duplicate, the current Graduate Bulletin published by the State University of New York at Stony Brook.

There are various decisions that every graduate student must make during the course of his or her career as a graduate student, and there are also decisions made about each student by the faculty. This handbook describes the procedures used by the faculty in making decisions, and describes when, how, and by whom, they are made. Students are urged to become familiar with this information so that they can intelligently plan their careers.

This Handbook also contains information about what is expected of you, both as a student and as a graduate trainee, if you are supported by the Department. There is also information about the criteria used to evaluate your work. By reading this, you can learn whom to talk to about each aspect of your work, and when and where you can have input into the decisions that affect you. You are urged to read it, as well as the Graduate Bulletin, carefully, so as to be well informed about a variety of matters that affect you and your graduate career.

Please bear in mind that the Department of Mathematics does not intend this handbook to be a collection of harassing rules and regulations, but rather as a guide to what is expected of our students. Any time you have an alternate proposal, before the fact, for some rule or regulation, you should feel free to talk to the Graduate Studies Director about it. We are always willing to make exceptions for good reasons.

2 ADMINISTRATION, STAFF, AND FACILITIES

This summary is confined to those functions and responsibilities related to the graduate program.

2.1 Graduate Program Committee

This committee consists of five members of the professorial faculty and two elected representatives of the graduate students; also the Chairman of the Department and the Director of Undergraduate Studies are ex-officio members.

The main function of this committee is to act for the Department in setting and approving policy for the graduate program. With the assistance of other members of the Department of Mathematics, the committee evaluates performances on the Comprehensive Examinations, and makes decisions concerning a student's support and continuation in the graduate program.

2.2 Graduate Studies Director

The Graduate Studies Director serves as chairman of the Graduate Program Committee and as executive officer of the Graduate Program. His job is to administer the graduate program in accordance with the policies set by the Graduate Program Committee. He is authorized to make a variety of decisions; some, only after consultation with appropriate members of the Department of Mathematics. He may be assisted by an Associate Director of Graduate Studies.

2.3 Director of Undergraduate Studies

The responsibilities of the Director of Undergraduate Studies include assignment, general supervision, and evaluation of all teaching assistants whose duties consist of classroom teaching, tutoring or paper grading. He is also responsible for working out each semester's teaching and assisting schedules, and for developing and supervising the undergraduate curriculum, and for advising all undergraduate mathematics majors. There are also one or more Associate Directors of Undergraduate Studies.

2.4 Associate Director of the Graduate Program

The Director of the Masters Program for Secondary School Teachers serves as executive officer of the Secondary Teacher Option of the Masters Program.

2.5 Assistant to the Chairman

The Assistant to the Chairman of the Mathematics Department is responsible for payrolls, academic record keeping, and for general supervision, and evaluation, of all graduate assistants who are assigned general departmental duties.

2.6 Graduate Secretary

The responsibilities of the Graduate Secretary include academic record keeping, distributing forms needed by graduate students, secretarial assistance to the Graduate Studies Director and other departmental administrators.

2.7 Office Facilities

The Mathematics Department occupies four floors of the Mathematics Building. The Undergraduate Studies office, the mailroom, and photocopying facilities are on the Plaza (ground) Level. The Mathematics Learning Center and the SINC site (computer facilities) are on the Service Level (below the Plaza level).

Each full time graduate student is assigned a desk (in a room shared with one or more other graduate students) and is provided with a key for his or her office, and a key to the building. Every graduate student is assigned a mailbox in the mailroom.

2.8 Photocopying Facilities

The Department of Mathematics has facilities for photocopying that are available to graduate students on the following basis:

Personal material — at cost.

Material for use in connection with teaching or office duties — free.

Materials for academic use — free, with approval of academic advisor.

The Department's photocopying budget is severely limited. Consequently, all photocopying charged to the Department of Mathematics must be carefully controlled. Each user receives an account number and is responsible for documenting the allocation of copies charged to that account to personal, departmental, and academic use. Students should be aware that it is illegal to photocopy books, or parts of books, except under certain limited circumstances.

Typing services in connection with teaching are quite limited. Many people do their own typing; there is a typewriter in the Undergraduate Office that can be used for this purpose. The

secretaries in the Undergraduate Office normally type syllabi and the common examinations for multi-section courses; they are also available for typing some other course material, especially when there is no reasonable alternative. No other typing services are available to graduate students. In particular, the Department of Mathematics does not provide graduate students with the service of having dissertations typed by the departmental staff.

2.9 Computer Facilities

The mathematics department has an extensive computer network, primarily using Linux and Solaris platforms, but also including Windows and Macintosh machines. There are computers in most faculty and graduate student offices as well as a number of workstations in public areas for use by students, faculty and visitors. In addition, there is an instructional lab with 30 Sun workstations and 25 Windows machines in which computer-related courses are taught. Several of the faculty and many graduate students use computation as an important part of their research.

In the rare event that more than one person might want to use a computer at the same time, we have rules of precedence. They are that faculty use takes precedence over graduate student use, and that mathematics (not including word processing) takes precedence over communication, which, in turn, takes precedence over word processing.

IMPORTANT: The department computer network is funded by state, federal and private money for our educational and scientific work. It does serve as a general communication device for the department, so some personal use is tolerated. However political and commercial use is not tolerated. Also there are special addresses such as "faculty", "grad" or "staff" and these are to be used only for department business. Items that someone may think have general interest, but that are not department business must not be sent to these addresses. Any student who uses the computer system inappropriately will have his computer privileges revoked.

2.10 Mathematics Library

The Mathematics Library, together with the Physics/Astronomy Library, is housed on the C level of the Physics Building (which is across the bridge from the fourth floor of the Mathematics Building). The library contains a broad range of books, as well as all important mathematics journals. There are also many specialized books and journals reflecting the research interests of the faculty. There are a total of 60,000 books, of which about 60% concern mathematics, and 50,000 bound journals, of which about 40% concern mathematics. The library subscribes to about 400 printed journals, of which 200 are in mathematics and there are more than 500 mathematics journals available with full text on-line. The library also subscribes to an on-line version of Mathematical Reviews, MathSci Net, along with other mathematics related research databases. Books not used in the past ten or more years and bound volumes of journals which have ceased publication or to which the Library does not currently subscribe are located in the

Science/Engineering Library in the Main Library Building.

During the semester, the library hours are usually as follows:

Monday - Thursday	8:30 a.m. - 10:00 p.m.
Friday	8:30 a.m. - 5:00 p.m.
Saturday	2:00 p.m. - 6:00 p.m.
Sunday	2:00 p.m. - 10:00 p.m.

During intercession, the library hours are usually:

Monday - Friday	8:30 a.m. - 5:00 p.m.

3 DEGREE PROGRAMS

The Department of Mathematics offers programs leading to the degrees of Master of Arts and Doctor of Philosophy.

3.1 Masters Program

This program consists of two options: the Secondary Teacher Option for secondary school mathematics teachers seeking permanent certification; and the Professional Option designed for students who plan careers as professional mathematicians in industry, government, finance, or academics.

The Secondary Teacher Option is a two-year part time program. It is designed for students who are currently secondary school mathematics teachers, and the courses all meet in the late afternoon or evening.

The Professional Option is designed as a full time one or two year program, depending on the background of the individual. Under special circumstances, students may also enroll in this program on a part time basis.

3.2 Doctoral Program

This program is designed for students who plan careers as research mathematicians and/or as college or university faculty. As a general rule, this program is available only on a full time basis. Completion of the doctorate usually requires four to five years.

3.3 Admission

Admission requirements are listed with the separate program descriptions below. In addition to the specific program requirements, the Graduate School requires all applicants to take the Graduate Record Examination. Under special circumstances, applicants may delay taking this examination until after they are admitted.

The Graduate School also requires that all foreign students demonstrate proficiency in English. This can be accomplished in a variety of ways; for prospective students who are overseas, and not residing in an English speaking country, the Graduate School requires a TOEFL score of 550 (213 if computer based) for all students. Students who are deficient in English (even if they have an acceptable TOEFL score) are required to correct this deficiency within one year at their own expense.

3.4 Graduate Council Fellowships

The Graduate School awards several Graduate Council Fellowships to outstanding incoming applicants each year. In order to be eligible for this award, the applicant must be a United States citizen, or permanent resident, and must have all application material (three letters of recommendation, official college transcript, and GRE scores) submitted to the Graduate School early in February (the exact deadline varies from year to year and can be ascertained by calling the Graduate Secretary, or by calling the Graduate School directly).

4 MASTER OF ARTS PROGRAMS

4.1 The M. A. Secondary Teacher Option

The secondary teacher option is a two-year part-time program designed for secondary school mathematics teachers who seek permanent certification. The courses are given in the evenings and in the summer, in a two-year cycle, each course being offered once every two years.

4.1.1 Admission

The minimum requirements for admission to this program are:

A. A bachelor's degree.

B. Two years of college level mathematics including one year of single variable calculus, one semester of linear algebra and one more semester of mathematics beyond single variable calculus.

C. Provisional New York State Certification for Teaching Mathematics, grades 7–12.

D. A grade-point average of 3.0 or better in all calculus and post-calculus mathematics courses.

E. Evidence that the student is likely to succeed: This usually includes three letters of recommendation from former teachers or supervisors.

F. Acceptance by both the Mathematics Department and the Graduate School.

4.1.2 Requirements for the M.A. Degree (Secondary Teacher Option)

The degree requirements are completion of a program of 30 graduate credits approved by the Director of the Masters Program for Secondary School Teachers, and passing the Secondary Teacher Option Comprehensive Examinations. These examinations consist of the final examinations of the core courses for teachers: Algebra, Analysis I and II, and Geometry, for Teachers. Normally, the required program includes:

MAT 511	Fundamental Concepts of Mathematics
MAT 512	Algebra for Teachers
MAT 513, 514	Analysis for Teachers I and II
MAT 515	Geometry for Teachers
MAT 516	Probability and Statistics for Teachers
MAT 517	Calcultors and Computers for Teachers
MAT 518	Seminar in the Uses of Mathematics
MAT 519	Seminar in Mathematics Teaching

a total of 9 one semester courses or 27 credits. One elective course, which is approved by the Director of the Masters Program for Secondary School Teachers, and is in a subject related to mathematics or mathematics education, may be taken to complete the required 30 credits.

Variations on this program will be considered for approval. For example, a student with a strong mathematics background may wish to replace some of the mathematics courses listed above by other graduate courses in mathematics, or subjects closely related to mathematics, or, in exceptional cases, by more education-oriented courses. Normally there will be no opportunity for students in this option to take supervised student teaching.

Students are permitted to transfer up to six credits of graduate work done elsewhere, in appropriate courses, for use towards the thirty credits required for the M.A. degree, subject to the approval of the Director of the Masters Program for Secondary School Teachers and of the Graduate School.

4.2 The Master of Arts Degree (Professional Option)

4.2.1 Admission

The minimum requirements for admission to this program are:

A. A bachelor's degree with a major in mathematics or equivalent mathematical training.

B. Evidence that the student is likely to succeed:

(a) This must include three letters of recommendation from mathematicians, usually the applicant's current or former teachers.

(b) A complete transcript of previous college studies including grades in all mathematics courses.

(c) Scores on the Graduate Record Examination, both the general exam and the mathematics exam.

(d) (for foreign students) Evidence of a good command of English. A TOEFL score of 550 or a computer-based score of 213 is satisfactory. It is not required for students from English speaking countries.

C. Acceptance by both the Mathematics Department and the Graduate School.

4.2.2 Requirements

A. Two consecutive semesters of full time work in a program approved by the Department.

B. At least 30 graduate credits.

C. A Grade Point Average of at least 3.0 in graduate courses taken at Stony Brook.

D. A passing grade (C or better) in the final examination of each of the following courses (or the equivalent): MAT 530, 531,534, 535, 542, 544, and 550; the overall average of the grades in these final examinations must be at least B. This requirement is waived for students who have passed the Ph. D. comprehensive examination.

E. A Satisfactory grade in the teaching practicum, MAT 598.

F. A three course minor in an area related to mathematics; the particular sequence of courses must have Departmental approval.

4.2.3 The Curriculum

The Master of Arts curriculum consists of the following courses, ordinarily taken in the order indicated.

Semester I (12 credits)	**Semester II (12 credits)**
MAT 530 Topology/Geometry I	MAT 550 Real Analysis I
MAT 534 Algebra I	MAT 542 Complex Analysis I
MAT 598 Teaching Practicum	MAT 531 Topology/Geometry II
MAT 544 Analysis	MAT 535 Algebra II
Semester III	**Semester IV**
Minors and Math Electives	Minors and Math Electives

All students must follow a course of study approved by the Department. A student who follows the above curriculum, and who passes all courses with a grade of C or better, with an overall B average, automatically has Departmental approval. Any student wishing to follow a different curriculum must have the approval of the Graduate Studies Director for his or her program.

4.2.4 The Problem Seminar

The problem seminar is designed to extend and unify the M.A. core courses by analyzing problems and exploring supplementary topics which relate to one or more of these courses. This seminar

is also designed to focus the student's preparation for the written Doctoral (Comprehensive) Examination.

4.2.5 The Teaching Practicum

All new Teaching Assistants are required to take the teaching practicum, MAT 598.

4.2.6 The Comprehensive Examination

The Masters Degree Comprehensive Examination consists of the final examinations in the following seven courses:

MAT 530, 531 Topology/Geometry I, II

MAT 534, 535 Algebra I, II

MAT 542 Complex Analysis I

MAT 544 Analysis

MAT 550 Real Analysis I

A student who for any reason does not take one of the above courses is nevertheless required to pass the final examination in that course, or an equivalent examination. The Masters Comprehensive requirement is waived for students who pass the doctoral comprehensive exam.

4.2.7 The Residence Requirement

Two consecutive semesters of full time study are required.

The purpose of the residence requirement is to ensure that students experience the stimulation of regular mathematical interaction with other students and with the faculty. Unusually mature individuals who present evidence of their ability to pursue graduate study in mathematics successfully without this interaction may be admitted on a part-time basis.

4.2.8 The Minor Requirement

A minor syllabus should consist of three courses in an area closely related to mathematics, such as physics, applied mathematics, computer science, statistics, economics, etc. Courses need not be at the graduate level, but the program must end at the graduate level; i.e., at the end of the three-semester sequence, the student should be adequately prepared to take graduate level courses in the minor subject. No freshman level courses may be counted towards the

minor requirement. Most lower division courses also will not be counted towards the minor requirement.

The minor requirement is independent of all other requirements; in particular, undergraduate courses, which may not be counted towards the 30 graduate credit requirement, may be counted towards the minor requirement. Similarly, courses taken before entering Stony Brook may be counted towards the minor requirement, but cannot be counted towards the residency requirement.

The minor syllabus must be approved by the Department; the Graduate Secretary has a standard form to be filled out. This approval should be obtained before any courses in the minor are taken. Students are responsible for ensuring that the courses listed in their syllabus are actually offered.

Students presenting earlier study (at a sufficiently high level) in an allied area may, at the discretion of the Graduate Studies Director, use this prior study towards satisfaction of the minor requirement.

4.2.9 Advanced Placement

Incoming students with a strong undergraduate background or previous graduate study may be advised to skip courses in the Masters curriculum. You may take the final examination without taking the course; however, in order to ensure that there are sufficiently many copies of the final examination, blue books, and chairs in the room, you should notify the appropriate professor, in advance, of your intention to take the final examination. For detailed syllabi of these courses, see Section 9.

Students are permitted to transfer up to six credits of graduate work done elsewhere, in appropriate courses, for use towards the thirty credits required for the M.A. degree, subject to the approval of the Graduate Studies Director and the Graduate School.

5 DOCTOR OF PHILOSOPHY PROGRAM

5.1 Admission to the Doctoral Program

The minimum requirements for admission to the doctoral program are the same as those for the Master of Arts Degree, Professional Option (see Section 4.1.1).

5.2 Admission to the Doctoral Program - Part Time

There is a one-year full time residence requirement; the reasons for this rule are given in Section 4.2.7.

5.3 Requirements for the Ph.D.

A. Passing the Doctoral Comprehensive (written) Examination.

B. Passing the Doctoral Preliminary (oral) Examination.

C. Demonstrating proficiency in reading mathematics in two languages other than English that are relevant to the candidate's field of study.

D. Two consecutive semesters of full time study as a student at Stony Brook in a program approved by the Mathematics Department.

E. Advancement to candidacy.

F. Satisfactory completion and defense of the Dissertation.

5.3.1 The Doctoral Comprehensive Examination

The purpose of the Doctoral Comprehensive Examination (known in the department as "Comps") is to test the mastery of the fundamentals in several core areas of mathematics. It is a written examination based on the syllabi of the seven core courses listed in Section 4.2.6; these syllabi are given in Section 9. The examination is offered twice each year, in January and in August.

5.3.1.1 Description of the Exam The exam is in two parts, each four hours long, and consisting of six questions based on the syllabi of the seven core courses, but slightly more difficult than the questions on the final exams of these courses. A student gets a perfect score if he does 10 problems completely correctly.

Sample questions, as well as past exams, are available on request from the Graduate Secretary.

5.3.1.2 Evaluation of Comps Identities of students are concealed by use of a coded designation for each individual. All answers to each question are graded independently by two faculty members. Scores of the exam are tabulated by a faculty member designated by the Graduate Studies Director. These tabulations are the basis of the evaluations made at a meeting of the Graduate Program Committee with the graders. The graded examination papers are available during the meeting should detailed comparison become appropriate.

When all examinations have been evaluated, the individual identities are made known. At that time, some negative decisions may be converted to positive decisions on the basis of course work and reports from faculty (this is a one way street; no positive decisions may at this time be changed to negative). Before the meeting, the Graduate Studies Director solicits reports from teachers of core courses on their students. These reports, together with all information volunteered by interested faculty members, is available at this last step of the evaluation meeting.

Students have the right to see your graded examination papers, and to discuss them with the graders. They can check for themselves that scores were added correctly, that no answer was overlooked, and that their intended meaning was understood by the grader. A student who wishes to do this should see the faculty member in charge of the examination.

5.3.1.3 Timetable for Taking/Repeating Comps A student may take the Comps any time that they are given, but a maximum of three times. As a general rule a student should have passed the Comps by the end of his or her third semester.

If a student has not passed the Comps by the end of his or her third semester, then he or she is not making satisfactory progress and may be subject to dismissal from the program at the end of the academic year. A student may petition the graduate director for permission to take the Comps one last time (at the end of his or her fourth semester), by presenting the graduate director with evidence of significant progress since the last time he took the exam or with strong letters of recommendation from the faculty. The graduate Director will then seek the advice of the Graduate Committee.

5.3.1.4 The Comps Requirement can be waived In rare cases students who enter with a master's degree from another university and who show convincing evidence of being prepared for research, may have the requirement of passing the Comprehensive Examination ("Comps") waived. This requires the approval of the Graduate Committee. A student who has the Comps waived must pass the Doctoral Preliminary Examination ("Orals") before the end of the second semester after admission.

5.3.2 The Doctoral Preliminary Examination

This examination is known in the Mathematics Department as "Orals". It is an oral examination administered by a faculty committee. The examination tests both your ability to learn advanced

mathematics, and your preparation for research in your major area. The emphasis on the test is a mixture of knowledge and application: one not only has to know the important results, and the interrelationships among them, but one also has to know how to apply these results in particular cases.

5.3.2.1 Orals Committee and Syllabus Each Orals Committee has three members: a major advisor, chosen by the student, a minor advisor, also chosen by the student, and a third member, chosen by the Graduate Studies Director. The major and minor advisors must be of professorial rank, including assistant and associate professors, in the Mathematics Department; exceptions to this rule must have the approval of the Graduate Studies Director.

The oral examination will cover two topics: a major topic and a minor topic. First a student should look for an advisor who is likely to become the student's dissertation advisor. This advisor will develop with the student a syllabus for the major topic. The material for this syllabus should be in quantity equal to that of a yearlong course, although it should not be the subject of an actual course. Part of the point of the preparation for the oral examination is for the student to read independently, pose questions about what he/she is reading and work out examples. During the preparation for the oral examination there should be interaction between the student and the advisor which will facilitate the advisor's directing the student after the examination is passed.

The minor topic can be suggested by the major advisor or by a second (minor) advisor. The minor topic can be complementary to the major topic or it can be a completely different second interest of the student. The material for the minor syllabus should be in quantity equal to that of a one semester course, although it should not be the subject of an actual course.

The oral examination should be taken within a year of passing the comprehensive examinations. For a student to remain in good standing, the oral examination must be passed within one and a half years from the time of passing the comprehensive examinations and at most three years from the beginning of graduate study. Students who begin their study with a master's degree will be expected to follow a shorter schedule.

The names of the committee members, and the syllabi, are recorded on a form that is available from the Graduate Secretary. This form also records a deadline, before which the examination must take place. This form is submitted to the Graduate Studies Director for approval and for the selection of a third member of the committee, who must also be of professorial rank in the Mathematics Department. The form is then sent to the Graduate School for approval.

5.3.2.2 Eligibility for Orals Students on probation may not organize an Orals Committee without the approval of the Graduate Studies Director; also, a student must pass the Comps before taking Orals (see 5.1 and 5.2). FIXME

5.3.2.3 Procedures When a student is ready to organize his or her Orals Committee, he or she, in conjunction with his or her major and minor professors, fills out a form (obtainable from the Graduate Secretary) listing the major professor, the minor professor, the syllabus for the examination, and a date by which the examination must be taken. This form should be given to the Graduate Secretary. If the Graduate Studies Director approves, then he or she will add a third member to the Committee. These arrangements must be made at least three weeks before the date of the examination, in order to allow time for the Graduate School to approve the membership of the Committee. It is then the student's responsibility to make all the arrangements for the Orals. He or she should arrange the date, time, and place with the members of your Orals Committee. He or she must notify the Graduate Secretary of these arrangements at least one week in advance of the date. The graduate secretary will provide the members of the committee with a copy of the syllabus, and will prepare an Orals report form for the Chairman of the Committee.

Members of the faculty who are not on the Committee may observe the Orals Examination only with the student's permission, and the permission of the Chairman of the Orals Committee.

After the examination, the Orals report form is signed by the members of the Committee and is then given to the Graduate Secretary; it is then placed in the student's file.

There are three possible outcomes to the Orals Examination: pass, pass with distinction, and fail. The Committee decides that a student's performance on the Orals merits a verdict of pass with distinction only if the student's performance has been outstanding in both major and minor topics.

If the Committee decides that the student has failed the examination, then the Committee must also decide whether or not to recommend a repeat. If the recommendation for a repeat is positive, then the Orals Committee will be supplemented by a fourth faculty member, chosen by the Graduate Studies Director. The repeat must ordinarily be scheduled within six months of the first attempt. A majority vote (3–1 or 4–0) of the Committee is required for a pass on the second attempt.

Ordinarily, the recommendation to repeat is withheld only when the Orals Committee decides, on the basis of the Orals Examination, that the student is very unlikely to improve sufficiently to pass on a second attempt.

The approval of the Graduate School is required for a second repeat.

5.3.2.4 Examiners' Responsibility Since the oral exam is the last step before the doctoral thesis, the examiners should make sure that any student who passes the exam has a thesis advisor available. It is most common that the major advisor becomes the thesis advisor, but any examiner may become the thesis advisor and any examiner may find a thesis advisor for the student. It is the major advisor's responsibility to ensure that a thesis advisor is available to a student who passes the oral exam even if he or she has to be the thesis advisor.

5.3.3 The Language Proficiency Examinations

The Mathematics Department requires that students show reading proficiency in two languages, other than English, in which there is substantial mathematical literature. The standard foreign languages are French, German, and Russian; these are always acceptable. Satisfaction of this requirement with any other foreign language requires approval of the Graduate Studies Director.

For students whose native language is not English, a note from the thesis advisor asserting that there is significant literature in the student's native language will satisfy the requirement for one of the two languages.

Normally, a student is expected to complete this requirement during the first four years of graduate study.

When a student is ready, he or she should choose one or two appropriate books and/or substantial journal articles to translate, and communicate this choice to the Graduate Studies Director (on a form available from the Graduate Secretary). After approving the choice, the Graduate Studies Director will help you find an examiner. The examiner must be a Department member of professorial rank or someone else approved by the Graduate Director.

The examination must take place within one month. The examiner chooses the pages to be translated, and sets a reasonable time limit. The student then writes out a translation of these pages, using a dictionary if desired. The examiner evaluates the translation in accordance with the above criterion, and enters the result on the Language Examination Form. It is the student's responsibility to then give the completed form to the Graduate Secretary.

5.3.4 The Residence Requirement

Two consecutive semesters of full time study are required. The purpose of the residence requirement is to ensure that students experience the stimulation of regular mathematical interaction with other students and with the faculty.

5.3.5 Advancement to Candidacy

This is primarily, but not necessarily, a formality; a form is filled out, and sent to the Graduate School. It takes place after you have met all degree requirements, except for the dissertation.

A student must have Advanced to Candidacy one year; that is, two semesters before he defends his or her dissertation

Students who have Advanced to Candidacy are regarded by the Graduate School as working independently on their dissertations. Tuition Scholarships for such students are limited to nine credits per semester; these must consist of nine credits of MAT699, unless otherwise approved by the Graduate Studies Director.

5.3.6 Time Limitation

There is a Graduate School requirement that a candidate for a Ph.D. must satisfy all requirements for that degree within seven years after completing 24 hours of graduate courses in the Mathematics Department. Except for authorized Leave of Absence, this is an absolute limitation; see Section 6.4.

One can petition to extend this time limit, provided the petition is endorsed by the Graduate Studies Director. The Department, and/or the Graduate School may require evidence that the student is still properly prepared for the completion of work. In particular, the student may be required to pass a new Oral Preliminary Examination in order to be permitted to continue work.

5.3.7 The Dissertation

After passing Orals, a student may ask any member of the faculty of professorial rank (including assistant and associate professors) to accept formal designation as thesis (dissertation) advisor. Under unusual circumstances, a thesis advisor may be chosen from outside the Mathematics Department; such a choice must be approved, before the fact, by the Graduate Studies Director, and by the Graduate School.

The usual choice of thesis advisor is the chairman, or another member, of the Orals Committee. However, the student is under no obligation to make that choice. Indeed, after passing the Orals, the student may choose to work in an entirely different branch of mathematics. However, the members of the Orals Committee are likely to be the faculty members most familiar with the student, and they voted to pass the student, certifying that he or she is adequately prepared to begin thesis research. There is, then, a presumption that at least one of the faculty members of the Committee would be willing to accept the student as a thesis student. It is the responsibility of the Committee to assist the student in finding an adequate thesis advisor, in the subject in which the student was examined. A student wishing to change subject is free to approach any faculty member of professorial rank to enquire if he or she would serve as thesis advisor.

In any event, the thesis advisor/advisee relationship commences and continues by mutual agreement and may be terminated by either party, although the Mathematics Department expects that members of its faculty and graduate students will not act arbitrarily in such matters (or any other matters), but will only take action for reasonable cause.

The Mathematics Department depends heavily upon reports of thesis advisors to make renewal of support decisions. It is therefore to the student's advantage to keep the Graduate Secretary informed of his or her thesis advisor's identity, and to keep the thesis advisor informed of your activities.

When your thesis advisor decides that your thesis is complete, he or she, in consultation with the Graduate Studies Director, chooses the members of your Dissertation Examining Committee. That Committee consists of your thesis advisor, at least two other members of the Mathematics

Department of professorial rank, one of whom will serve as chairman, and at least one outside member. The outside member must also have professorial rank, either in the mathematics department of another university, or in another department of this university. The outside member should be knowledgeable in your field.

The Graduate Studies Director also designates a second reader; this is done in consultation with the thesis advisor. The thesis advisor and second reader are each required to submit a brief written evaluation of the thesis to the Graduate Studies Director. These evaluations both confirm the technical correctness and originality of the main results in the thesis, and include reasons why the thesis should be accepted as a doctoral dissertation. (G. H. Hardy's criteria were: "Is it true? Is it new? Is it interesting?") The written reports of the two readers must be circulated to the members of the Dissertation Examining Committee before the thesis defense takes place. The reports then become a permanent part of the student's file.

The student must prepare his or her written thesis in a form acceptable to the Graduate School. The Graduate School publishes a set of rules in the Graduate Bulletin that a student should consult before writing the final draft of your thesis. The final copy must be written in accordance with the rules stated there.

The Graduate Studies Director must submit the membership of the Dissertation Examining Committee to the Graduate School for approval. This approval is contingent on the student's Advancement to Candidacy having already taken place.

The student is responsible for making all arrangements for the thesis defense. Specifically, he or she should provide the members of the Dissertation Examining Committee, and the Graduate Studies Director, with typed copies of the thesis and should arrange with them a date, time, and place for the thesis defense. The student should notify the Graduate Secretary of these arrangements and the graduate secretary will then post announcements of the pending thesis defense, and distribute copies of the announcements to the members of the Committee. The defense must be open to all interested parties.

Note: Public announcement of the thesis defense must occur at least one week prior to the defense.

The copy of the thesis given to the Graduate Studies Director will be placed in the office of the Graduate Secretary for examination by any interested person.

The student should prepare, or ask the Graduate Secretary to prepare, a thesis approval page for the Committee in the form specified by the Graduate School. All signatures on this page must be in permanent black ink (not felt tip).

After the thesis defense, the student must submit to the Graduate Studies Director a photocopy of the signed thesis approval page. He or she must also submit three copies of the thesis to the Graduate School, each copy containing a signed thesis approval page. One copy, after being bound, goes to the Mathematics Department for inclusion in the Department's public thesis collection. A second bound copy is placed on the open shelf in the Library Thesis Room. The

original thesis is placed unbound in the Library Archives.

See Section 6.6 for graduation procedures.

6 ACADEMIC POLICIES, REGULATIONS, AND PROCEDURES

6.1 Academic Advisors

Members of the Mathematics Department who serve as academic advisors to graduate students are expected to assist the Graduate Studies Director in evaluating academic progress and in making recommendations for renewal of support. They are also asked to make sure that their advisees' course selections conform with the policies described in the next section, 6.2. Above all, they are expected to be the principal point of contact between their advisees and the Department.

The Graduate Studies Director will make assignments of students to academic advisors that are agreeable to all parties involved. Initial assignments are made as follows in the absence of specific requests.

The Director of the Masters Program for Secondary School Teachers is academic advisor to all students in the Secondary Teacher Option of the Masters Program.

The Graduate Studies Director is the academic advisor to all other new students. The Graduate Studies Director will assign each student to a faculty member who will be that student's advisor until the student has found a major advisor for the Orals Examination. This advisor will then become the student's advisor. If the student eventually has a thesis advisor other than the major advisor for the orals, the thesis advisor will become the advisor for the student.

6.2 Registration – Course Selections

One or two days at the start of each semester are set aside for graduate registration. (Late registration rules and fees are described in the Graduate Bulletin.) If a student does not receive a packet of registration materials by mail, he or she may be pick one up in the office of the Graduate Secretary.

Academic advisors are generally available before and during registration. Incoming students should see the Graduate Studies Director for advice on course selections. There are a few restrictions on the courses you may elect.

To begin with, full time students without prior graduate study must register for at least 12 credit hours in a program of courses approved by the Department. One or two of these courses may be outside the Department, provided your advisor approves. A full time student beyond the first year of graduate study, who has not yet advanced to candidacy, must register for at least 9 credits each semester. After he has advanced to candidacy, he must register for 9 credits each semester; these must consist of nine credits of MAT 699, unless otherwise approved by the Graduate Studies director.

Students with Departmental support should be aware that, as a general rule, the minima above

are also maxima; that is, Tuition Scholarships do not normally cover more than full time study, as defined above. Thus a student who registers for more than the minimum number of credits will be obliged to pay the additional tuition.

6.3 Satisfactory Progress

Students in the program are expected to work towards mathematical maturity. It is in general quite difficult to measure the extent to which a student is working, and the extent to which the student is maturing mathematically as a result. A student who is maturing mathematically at an acceptable rate is said to be making satisfactory progress. A student who is not making satisfactory progress may be placed on probation, may have his or her support terminated, or both. A student on probation, who is not making satisfactory progress, may be dismissed from the program. Whether or not a student is making satisfactory progress is a purely academic question; renewal of support decisions are based on both satisfactory progress and satisfactory performance of duties.

6.3.1 Normal Yardsticks for Academic Progress

For students in the early stages of graduate study, there are relatively easy sufficient conditions for satisfactory progress.

A. During the first two years of graduate study, a student who maintains full-time status, passes all courses, and maintains an overall B average (3.0 on a scale of A = 4) is making satisfactory progress.

The remaining criteria affect only students in the Ph.D. program.

B. A student who passes Comps by the end of the third semester is making satisfactory progress.

C. A student who passes Orals by the end of the fifth semester, or within one year of passing Comps, if that is later, is making satisfactory progress.

If you do not meet these criteria, but believe that these examinations do not accurately measure your mathematical progress, you should discuss this with the Graduate Studies Director.

For students who have passed Orals, and are working on their dissertations, satisfactory progress is primarily a question of mathematical maturity and is difficult to measure. The advisor of each such student is asked each year to give a written evaluation of the student's progress, which the student may read and respond to. If the advisor says that the student is not making satisfactory

progress, and the student disagrees, the student may appeal to the Graduate Studies Director (see Section 7.5).

In the absence of a written report from the thesis advisor, a student who has passed Orals is presumed to be making satisfactory progress if not more than three semesters have elapsed since the student passed Orals, and not more than four years have elapsed since the student entered the program. However, see Section 7.4 for differences in level of support and time limitations.

All students are expected to have advanced to candidacy by the end of their third year.

Students who are unsure of how well they are progressing are encouraged to seek an assessment at any time from their instructors, their Orals chairman, their thesis advisor, or the Graduate Studies Director. Thesis students, in particular, are entitled to regular feedback from their dissertation advisors. If this feedback is not forthcoming, the matter should be discussed with the Graduate Studies Director.

6.3.2 Probation

A student placed on probation by the Department of Mathematics is thereby warned of his or her failure to maintain satisfactory progress. This probationary status will end if and when the conditions specified at the start of probation are met. If these conditions are not met within the specified time, the student may be dismissed from the program. This is the only penalty associated with probation; probationary status is not recorded on any student's transcript. Also, there are circumstances under which a student may be placed on probation while continuing to be supported. It is not required that dismissal or termination of support be preceded by probation.

6.3.3 Grades

Grades authorized by the Graduate School are A, A-, B+, ..., C-, and F. The grades S and U (Satisfactory and Unsatisfactory) may be used only where the normal mode of evaluation is impractical and then only with specific approval by the Graduate Council. Currently, approval exists for the Problem Seminar, Teaching Practicum, Independent Study and Directed Research. The grade P (Pass) is not authorized for use in the Graduate School.

Temporary Grades of I (incomplete) and NR (No Record) are also sometimes used. You should be aware of the fact that, unless action is taken, these turn into Grades of F at some point during the semester following the one in which they are given. (the exact date appears in the Academic Calendar).

Graduate School policy is that for students who have completed three or more semesters of graduate work, an average below B (3.0) may be grounds for dismissal.

Grades in the core courses are based upon both homework and final examinations; they are

used by the Department as indicators of achievement and progress for beginning students. High grades in more advanced courses do not necessarily indicate significant achievement; however, low grades in advanced courses are indicative of serious problems.

6.4 Maintenance of Matriculation

The Graduate School requires that students who withdraw (that is, who are registered during one semester and do not register for the following semester) must apply for readmission to resume their graduate work at Stony Brook. You should note that the time limitations of Section 5.3.6 are suspended only for students who are on official Leave of Absence.

If you find it necessary to interrupt your matriculation, you may ask the Graduate Studies Director to seek approval from the Graduate School for a Leave of Absence for one year (this can be renewed for a second year). You should however be aware that, after a Leave of Absence, you will need to be readmitted to the Graduate School; the conditions for readmission should be stated in the Leave of Absence Form.

6.5 Continuation of Registration

Occasionally, a student who has completed all requirements for a Ph.D. except for the dissertation will wish to maintain his or her status as a student in the Department even though no longer a full time student; this usually occurs when a student is no longer supported by the Department. This will be permitted on a year-to-year basis, provided the student is making satisfactory progress. The thesis advisor of such a student will be asked for a progress report each semester to determine if satisfactory progress is being made.

6.6 Graduation

When a student has met all requirements for a degree, the Graduate Studies Director so informs the Graduate School. If a student wishes to graduate (that is, to participate in Commencement and/or to receive a diploma), another formality must be attended to: the student must submit a signed degree card to the Registrar. Consult the Academic Calendar for each semester's deadline for submitting degree cards, as well as for other relevant deadlines.

To graduate at the end of a term (Fall semester, Spring semester, or Summer session), you must be registered during that term for at least one credit hour, and all degree requirements must be met before a certain degree deadline for that term (this deadline is listed on the Academic Calendar). If the degree requirements are met after the deadline, but before registration for the following term, a student may graduate the following term (provided a Completion Statement has been submitted by the Department to the Graduate School before the beginning of the next semester). There is no need to register for the following term.

7 FINANCIAL ASSISTANCE

Four kinds of financial assistance are administered by the Mathematics Department: **Teaching** and **Graduate Assistantships**, assigned to the Department by the Graduate School, **Research Assistantships**, funded primarily from research grants held by members of the Department, and administered by the Chairman of the Department, **Tuition Scholarships**, and **Summer Support**.

Within the Department, little distinction is made among Teaching, Graduate, and Research Assistantships; they are all treated simply as **Assistantships**. Most full time students in the Masters and Doctoral programs are supported by Assistantships with Tuition Scholarships.

7.1 Graduate Council Fellowships

Incoming students whose admission files are complete by early February may be nominated to be Graduate Council Fellows. Graduate Council Fellows are selected in a university-wide competition, and receive a three-year award. Graduate Council Fellows must be American citizens or permanent residents.

7.2 Unsupported Students

Students sometimes enter without support. Also students whose past record is deficient are sometimes admitted unsupported to give them a chance to demonstrate their abilities. Such students will be considered without prejudice for support for the following year.

7.3 Continuation of Support

Continuation of support through the academic year is contingent on satisfactory progress. However, the Department of Mathematics may terminate support **during** the academic year only for cause. Examples are gross negligence, or abuse of power.

7.4 Renewal of Support

Supported students who are making satisfactory progress academically (see Section 6.3.1), who have performed their duties satisfactorily, and who have been graduate students in the Mathematics Department for at most four years will have their support automatically renewed, subject to availability of funds.

Students in their sixth and seventh years (not counting time on Leave of Absence), who have advanced to candidacy, are sometimes supported; this is an individual decision based on the

particular individual's mathematical progress, as given by the thesis advisor's report, and his or her performance of duties. It is also dependant on availability of funds. Even students who are making satisfactory progress, as defined in section 6.3.1, but who are in their sixth or seventh year, will be supported only at minimal levels.

Students are not supported beyond their seventh year (not counting time spent while on Leave of Absence).

7.5 Timing of Support Decisions - Appeals Procedures

Support decisions for the coming academic year are made during the spring semester. Notices to thesis advisors asking for reports on thesis students are sent out in February; these are returned to the Graduate Studies Director by March 1. The Graduate Studies Director decides, by March 31, whether or not the student will be supported for the coming academic year, and informs the student of his or her decision. The student will receive a copy of the thesis advisor's report, and a copy of any relevant material concerning the student's performance of duties.

The student has until April 15 to appeal this decision. The appeal, which must be made in writing, is to the Graduate Studies Director. The Graduate Studies Director will then meet with the student and the student's advisor, or other faculty members, as appropriate, and try to work out an agreement that will be satisfactory to both the student and the Department.

If no agreement has been reached by April 30, the student may then carry the appeal to the Department Chairman, who together with the Graduate director will make the final decision.

7.6 Allocation of Departmental Resources

Resources are allocated in the following order. First, support is allocated for continuing students who are making satisfactory progress mathematically, are performing their duties satisfactorily, and have not yet completed five years of graduate mathematics study at Stony Brook. Any further resources are then allocated to ensure a sufficiently large first year class. Since offers to prospective graduate students are made starting in early February, these allocations are made in late January, after the grading of the January Comps.

If there are further resources to be allocated, these allocations are made on a continuing basis during the spring semester and summer. These allocations are made by the Graduate Studies Director with the following two aims: (i) fairness to current graduate students, and (ii) maintenance or improvement of the quality of the graduate student body.

During the spring semester, students who wish to be supported for the coming year, and who either are in their fourth semester and have not passed Comps, or are in their sixth semester and have not passed Orals, or are in their tenth semester or beyond, should consult with the Graduate Studies Director to find out what the financial situation is, and what possibilities there

are for further support.

7.7 Summer Support

The Mathematics Department has some resources available for students who continue their studies during the summer. The amount of support varies and there are different categories of duties; see 8.2. Students who receive summer support are assumed to be spending the summer studying mathematics, and must be on campus for most of the summer. The major exception to this rule is for students who travel to mathematics meetings and workshops.

Students who are eligible for work-study grants (only U.S. citizens and permanent residents are eligible) will receive Departmental summer support only if they have applied for, but not received, a work-study grant.

8 DUTIES AND RESPONSIBILITIES

8.1 Assignments

Teaching, tutoring, and paper grading assignments are made by the Director of Undergraduate Studies, in consultation with the Graduate Studies Director. Research and general assignments are made by the Assistant to the Chairman, in consultation with the Graduate Studies Director.

8.2 Duties

As a general rule, the Mathematics Department attempts to assign duties that are consistent with the duties of academic mathematicians; i.e., teaching, tutoring, paper grading, and research. There is also a small amount of proctoring and general office work.

Assistants are expected to work during the semester, and are assigned work accordingly. This usually means a load of teaching one undergraduate course, or grading papers for one beginning graduate course, or some combination of teaching recitation sections, grading papers, and tutoring in the Mathematics Learning Center.

Each full-time teaching assistant is expected to hold three office hours per week, one of which must be in the Math Learning Center.

There are no required duties for a teaching assistant during the summer break. However, if a student wishes to earn extra money during the summer break, this is sometimes possible through the Work-Study Program, summer teaching or research work.

8.3 Supervision

Each individual assignment of duties is accompanied by the designation of a supervisor. This supervisor (a member of the staff or faculty) tells each assistant assigned to him or her what the assistant is supposed to do, and when to do it. It is the mutual responsibility of supervisor and assistant to reach explicit understanding on the assistant's responsibilities, including such things as scheduling office hours, proctoring exams, and grading papers.

The supervisor is expected to make sure that assignments are carried out adequately. Especially in the case of academic assignments, the supervisor is expected, in consultation with the Director of Undergraduate Studies, to take appropriate steps when necessary to improve the teaching done by each assistant assigned to him or her. At term's end, each supervisor will be asked to evaluate the performance of the assistants assigned to him or her.

8.4 Responsibilities

As a general statement, assistants are expected to act responsibly, rationally, and ethically. It is difficult to spell out the exact meaning of these terms; an attempt is made in a job description statement that each assistant must sign at the beginning of each semester. In broad terms, the job description outlines the general duties of an assistant, explains how and why one should carry out the duties conscientiously, indicates behavior that is unacceptable, and describes the evaluation procedure and other aspects of due process.

8.5 Outside Tutoring

The Department receives requests from various individuals and institutions looking for mathematics tutors. The secretary in the Undergraduate Studies Office (P-143) keeps a list of these for the use of the graduate students. It is expected that students will not take on additional tutoring to the detriment of their studies and duties. In order to avoid even the appearance of unethical behavior, assistants are not permitted to accept payment for tutoring Stony Brook undergraduates.

9 CORE COURSE CURRICULA

Syllabi for the Core M.A. Courses (Professional Option)

The syllabi that follow list the topics in the core courses that students are expected to be familiar with for the Comprehensive Examination. A few of these topics may not be covered in a given offering of the course. Such topics should be studied independently by students in preparation for the Comps.

Topology/Geometry I (MAT 530)

1. Basic point set topology

- Metric Spaces
- Topological spaces and continuous maps
- Comparison of topologies
- Separation axioms and limits
- Countability axioms, the Urysohn metrization theorem
- Compactness and paracompactness, the Tychonoff theorem
- Connectedness
- Product spaces
- Function spaces and their topologies, Ascoli's theorem

2. Introduction to algebraic topology

- Fundamental group
- Fundamental group of S^n; examples of fundamental groups of surfaces
- Seifert-van Kampen theorem
- Classification of covering spaces, universal covering spaces; examples
- Homotopy; essential and inessential maps

Typical references

- James R. Munkres, *Topology: a first course*, Prentice Hall, Englewood Cliffs NJ, 1975;
- William S. Massey, *Algebraic topology: an introduction*, 4^{th} corrected printing, Springer-Verlag, 1977.

Topology/Geometry II (MAT 531)

1. Differentiable manifolds and maps

- Inverse and implicit function theorems
- Submanifolds, immersions and submersions

2. The tangent bundle

- Vector bundles, transition functions
- Reconstruction of a vector bundle from transition functions
- Equivalence classes of curves and derivations; tangent vectors
- The tangent bundle of a manifold as a vector bundle, examples
- Vector fields, differential equations and flows
- Lie derivatives and bracket

3. Differential forms

- Exterior differential, closed and exact forms
- Distributions, foliations and Frobenius integrability theorem
- Poincaré Lemma

4. Integration

- Stokes' Theorem
- Integration and volume on manifolds
- De Rham cohomology
- Chain and cochain complexes
- Homotopy theorem
- The degree of a map
- The Mayer-Vietoris theorem

Typical references:

- Michael Spivak, *A Comprehensive introduction to differential geometry*, 2^{nd} ed., Publish or Perish, Berkeley 1979;
- Glen Bredon, *Topology and geometry*, Springer-Verlag, 1993.

Algebra I (MAT 534, Fall semester)

1. Groups (5 weeks)

- Direct products, Normal subgroups, Quotient groups, and the isomorphism theorems.
- Groups acting on sets; orbits and stabilizers. Applications: class formula, centralizers and normalizers, centers of finite p-groups. Conjugacy classes of S_n
- Sylow's Theorems, Solvable groups, Simple groups, simplicity of A_n. Examples: Finite groups of small order (≤ 8).
- Structure of finitely generated abelian groups. Free groups. Applications.

References: Lang, Chapter I; Dummit and Foote, Part I; Rotman.

2. Basic linear algebra (3 weeks)

- Vector spaces, Linear dependence/independence, Bases, Matrices and linear maps. Dual vector space, quotient vector spaces, isomorphism theorems.
- Determinants, basic properties. Eigenspaces and eigenvectors, characteristic polynomial.
- Inner products and orthonormal sets. Spectral theorem for normal operators (finite dimensional case).

References: Lang, Chapters XIII and XIV; Dummit and Foote, Chapter 11.

3. Rings, modules and algebras (6 weeks)

- Rings, subrings, fields, ideals, homomorphisms, isomorphism theorems, polynomial rings.
- Integral domains, Euclidean domains, PID's. UFD's and Gauss's Lemma ($F[x_1, \ldots, x_n]$ is an UFD). Examples.
- Prime ideals, maximal ideals. The Chinese remainder Theorem. Fields of fractions.
- The Wedderburn Theorem (no proof). Simplicity and semisimplicity.
- Noetherian rings and the Hilbert Basis Theorem.
- Finitely generated modules over PID's, the structure theorem.

References: Lang, Chapters II, III, V, and VI; Jacobson, Chapter 2; Dummit and Foote, Part II.

Typical References:

- S. Lang, *Algebra*,
3^{rd} ed., Addison-Wesley, 1993.

- Jacobson, *Basic Algebra*,
  2^{nd} ed, W.H. Freeman, New York, 1985, 1989.
- Dummit and Foote, *Abstract Algebra*,
  2^{nd} ed, John Wiley, 1999.
- Rotman, *Introduction to the Theory of Groups*,
  Springer Verlag.

Algebra II (MAT 535, Spring semester)

1. Linear and multilinear algebra (4 weeks)

- Minimal and characteristic polynomials. The Cayley-Hamilton Theorem.
- Similarity, Jor'dan normal form and diagonalization.
- Symmetric and antisymmetric bilinear forms, signature and diagonalization.
- Tensor products (of modules over commutative rings). Symmetric and exterior algebra (free modules). $\mathrm{Hom}_R(-,-)$ and tensor products.

References: Lang, chapters XIII and XIV; Dummit and Foote, Chapter 11.

2. Rudiments of homological algebra (2 weeks)

- Categories and functors. Products and coproducts. Universal objects, Free objects. Examples and applications.
- Exact sequences of modules. Injective and projective modules. $\mathrm{Hom}_R(-,-)$, for R a commutative ring. Extensions.

References: Lang, chapter XX; Dummit and Foote, Part V, 17.

3. Representation Theory of Finite Groups (2 weeks)

- Irreducible representations and Schur's Lemma.
- Characters. Orthogonality. Character table. Complete reducibility for finite groups. Examples.

References: Lang, chapter XVII; Dummit and Foote, Part VI; Serre.

4. Galois Theory (6 weeks)

- Irreducible polynomials and simple extensions.
- Existence and uniqueness of splitting fields. Application to construction of finite fields. The Frobenius morphism.
- Extensions: finite, algebraic, normal, Galois, transcendental.

- Galois polynomial and group. Fundamental theorem of Galois theory. Fundamental theorem of symmetric functions.
- Solvability of polynomial equations. Cyclotomic extensions. Ruler and compass constructions

Typical References:

- S. Lang, *Algebra*,
  3^{rd} ed., Addison-Wesley, 1993.
- Jacobson, *Basic Algebra*,
  2^{nd} ed, W.H. Freeman, New York, 1985, 1989.
- Dummit and Foote, *Abstract Algebra*,
  2^{nd} ed, John Wiley, 1999.
- Hungerford, *Algebra*,
  Springer-Verlag, 1974.
- B.L. van der Waerden, *Algebra*,
  Springer-Verlag, 1994.
- Blyth, *Module Theory*,
  Oxford University Press, 1990
- J.-P. Serre, *Linear representations of finite groups*,
  Springer-Verlag, 1977

Complex Analysis I (MAT 542)

1. The field of complex numbers, geometric representation of complex numbers

2. Analytic functions

- Definition, Cauchy-Riemann equations
- Elementary theory of power series, uniform convergence
- Elementary functions: rational, exponential and trigonometric functions
- The logarithm

3. Analytic functions as mappings

- Conformality

- Linear fractional transformations
- Elementary conformal mappings

4. Complex integration

- Line integrals and Cauchy's theorem for disk and rectangle
- Cauchy's integral formula
- Cauchy's inequalities
- Morera's theorem, Liouville's theorem and fundamental theorem of algebra
- The general form of Cauchy's theorem

5. Local properties of analytic functions

- Removable singularities, Taylor's theorem
- Zeros and poles, classification of isolated singularities
- The local mapping theorem
- The maximum modulus principle, Schwarz's lemma

6. The calculus of residues

- The residue theorem
- The argument principle
- Rouche's theorem
- Evaluation of definite integrals

7. Power series

- Weierstrass theorem
- The Taylor and Laurent series
- Partial fractions and infinite products
- Normal families

8. The Riemann mapping theorem

9. Harmonic functions

- The mean-value property
- Harnack's inequality
- The Dirichlet problem

Typical references:

- Lars V. Ahlfors, *Complex analysis: an introduction to the theory of analytic functions of one complex variable*,
  3^{rd} ed.; McGraw-Hill, 1979;
- John B. Conway, *Functions of one complex variable*,
  2^{nd} ed.; Springer-Verlag, 1978.

Analysis (MAT 544, Fall semester)

1. Advanced Calculus/Ordinary Differential Equations ("ODE")

- Review of the real number system
- Metric spaces, continuity, uniform convergence
- Contraction mapping principle
- Existence and uniqueness theorems for ODE
- Global existence theorem for linear ODE
- Linear transformations, orthogonal projections and matrix exponential
- Linear systems of ODE with constant coefficients
- Derivatives in $\mathbf{R}^n$ and in Banach spaces
- Newton's method and the inverse function theorem
- The implicit function theorem

2. Measure theory

- Riemann integral in $\mathbf{R}^n$
- Cantor-type sets, dyadic decompositions in $\mathbf{R}^n$
- Measures arising from volume functions on open sets
- Basic properties of the Lebesgue measure
- Measurable and integrable functions
- Convergence theorems for Lebesgue integrals: monotone and dominated convergence theorems and Fatou's lemma
- Criterion for Riemann integrability

Typical references:

- Daryl Geller, *A first graduate course in real analysis. Part I*, Solutions Custom Publishing (can be ordered from the campus bookstore);
- Walter Rudin, *Principles of mathematical analysis*, 3^{rd} ed., McGraw-Hill, New York 1976;
- Walter Rudin, *Real and complex analysis*, 3^{rd} ed., McGraw-Hill, New York 1987;

Real Analysis I (MAT 550, Spring semester)

1. Brief discussion of the measure theory

- Riesz Representation Theorem
- Tonelli's and Fubini's Theorems
- The dual of L^1
- Radon-Nykodim Theorem
- Lebesgue's Theorem
- Hahn Decomposition Theorem

2. L^p spaces, convergence in measure, the dual of L^p

3. Fourier series

- Riemann-Lebesgue lemma
- Convergence of Fourier series for differentiable functions
- Parseval's formula

4. Functional analysis

- Open mapping and closed graph theorems
- Uniform boundedness principle
- Hahn-Banach theorem
- Existence of orthonormal bases for Hilbert spaces
- Maximal operator controlling sequences of operators between Banach spaces

5. More measure theory

- Maximal operators controlling almost everywhere convergence
- The fundamental theorems of calculus for the Lebesgue integral

- Change of variables of integration
- Polar coordinates

6. Partial Differential Equations

- Separation of variables
- The heat equation
- Laplace's equation, the fundamental solution
- The strong maximum principle and the Liouville theorem
- The mean-value theorem
- The Poisson kernel
- Approximate identities and the Weierstrass theorem on approximation by polynomials
- The wave equation, d'Alembert's solution

Typical references:

- Daryl Geller, *A first graduate course in real analysis. Part II*,
  Solutions Custom Publishing (can be ordered from the campus bookstore);
- Walter Rudin, *Principles of mathematical analysis*,
  3^{rd} ed., McGraw-Hill, New York 1976;
- Walter Rudin, *Real and complex analysis*,
  3^{rd} ed., McGraw-Hill, New York 1987;
- Michael Taylor, *Partial differential equations*,
  Springer Verlag, 1996.