UNIVERSITY OF PUERTO RICO
RIO PIEDRAS CAMPUS
FACULTY OF NATURAL SCIENCE
DEPARTMENT OF MATHEMATICS

GRADUATE PROGRAM RULES

MARCH 2007

Table of Contents

I. GENERAL STATEMENT

The Department of Mathematics offers a Graduate Program, which can lead to the M.S. degree or to the Ph.D. degree. The Office of Graduate Studies of the Department of Mathematics provides administrative support for the program. The Graduate Committee of the Department of Mathematics sets broad policies to achieve the basic goals of assuring an effective program providing students the maximum opportunity to earn advanced degrees and maintaining standards for the degrees. The Committee also serves as an advisory body on admissions, curricula, and eligibility for graduate degrees. The Chairman of the Department takes into account the recommendations of the Coordinator of the Graduate Program and of the Graduate Committee to make decisions concerning the awarding and renewal of teaching assistantships.

General regulations of the Graduate School are listed in this document as well as specific policies of the Department. These policies should be carefully considered by all graduate students in planning their work towards an advanced degree. Additional information is available in the Office of Graduate Studies of the Department of Mathematics.

II. ADMISSION TO GRADUATE STUDY

Admission will usually be granted to applicants who have demonstrated ability and interest in mathematics. Grades of "B" or better in an undergraduate mathematics curriculum will usually qualify a student for admission; a "B" average or better in advanced courses is expected. The applicants should take the Graduate Record Examination Subject Test in Mathematics. A percentile rank above 50 is required for admission to the Ph.D.

program. It should be emphasized that admission to graduate status does not guarantee that a student will be able to earn a degree.

In order to ensure a more or less homogeneous level of preparation of students with different and varied educational backgrounds who will apply for admission to the graduate program, the applicants are required to have taken the following courses at the under-graduate level (this does not exclude that certain areas of specialization in the graduate program have particular requirements; for example, there is an undergraduate prerequisite for the graduate graph theory course, which in turn is a prerequisite for enumerative combinatorics):

1. Introduction to Mathematical Analysis (Advanced Calculus), including Differential and Integral Calculus of Several Variables. This requires the equivalent of 6 credits and can be based on the following textbooks:
   a. W. Rudin, *Principles of Mathematical Analysis*
   b. T.M. Apostol, *Mathematical Analysis*
   c. W.R. Wade, *Introduction to Analysis*
   d. S.A. Douglass, *Introduction to Mathematical Analysis*
   e. R.S. Borden, *A Course in Advanced Calculus*
2. Introduction to Modern Algebra, including the basic number systems, elements of group theory, of the theory of rings, fields (including polynomial rings), vector spaces, linear transformations, and the elementary theory of matrices. This requires the equivalent of 9 credits and can be based on the following textbooks:
   a. W.E. Deskins, *Abstract Algebra*
   b. Allan Clark, *Elements of Abstract Algebra*
   c. J. Landin, *An Introduction to Algebraic Structures*

Linear Algebra is an essential part of the requirements and cannot be ignored.

An applicant whose record is less than ideal may be admitted provisionally. Such a student must achieve at least a "B" for each course during the first year and must earn grades of at least "B" in any courses specified in the terms of admission. Provisional status lasts only one year.

A student in the Ph.D. program whose record does not prove of having taken the equivalent of 6 credits in Mathematical Analysis and the equivalent of 9 credits in Modern Algebra at the undergraduate level, as described above in points 1 and 2, must enroll in the corresponding pre-graduate courses in Algebra (MATH 5101-5102) and Analysis (MATH 5301-5302). The credits for these courses will not count towards the fulfillment of the requirements for a graduate degree.

An applicant who has been admitted provisionally before the completion of a standard undergraduate preparation must submit to the Graduate Committee a final official transcript after the degree has been awarded.

The admission status may be terminated if a graduate student's overall average stays below "B" for an extended period (usually two consecutive semesters).

III. GENERAL REQUIREMENTS

A. ADMISSION POLICIES

1. As stated above, admission can be granted to the Graduate Program in Mathematics to applicants who have obtained a bachelor's degree in mathematics or its equivalent, with an average of "B" or better, and who have taken as described in Section II:
   a. The equivalent of 6 credits in undergraduate Mathematical Analysis (Advanced Calculus), including Advanced Calculus of Several Variables, and

b. The equivalent of 9 credits in undergraduate Modern Algebra, including Linear Algebra.

An applicant who does not meet these requirements can be admitted provisionally, but the required conditions must be met during the year following admission.

2. Due to the enhanced level of preparation given in the graduate program offered by the Department of Mathematics, at most one third (1/3) of the graduate level courses required for a graduate degree taken at another university can be credited provided:

   a. The Graduate Committee agrees that the specific credits are acceptable in the student's program. The student must submit the official copies of the transcripts and of the descriptions of the courses for which transfer of credit is requested.

   b. The student obtained a grade of "B" or better in the courses for which transfer of credit is requested. No courses with pass/fail grades will be accepted.

   c. The credits were earned within five years prior to the date of entrance to the Graduate Program.

   d. The courses received graduate credit at the institution where they were taken, and have not been used to satisfy the requirements for any degree previously earned at the same graduate level or higher or at the undergraduate level.

3. The students who are in the M.S. program of our Department will continue according to the present rules until they get the M.S. degree.

4. The students who were enrolled in a master's or a doctoral program in mathematics at the Río Piedras Campus of the University of Puerto Rico or at any other university, and who wish to enroll in the Ph.D. program of the Department of

Mathematics, must satisfy the Graduate Program's criteria for admission. Courses used to satisfy the requirements for a previously earned degree at the same graduate level or higher or at the undergraduate level cannot be used to satisfy the course requirements for another degree. For the purpose of not having to repeat specific course requirements of the Ph.D. program, the students must

a. submit official transcripts of the grades for the courses for which credit is requested; these should have a grade of "B" or better.

b. submit official copies of the descriptions of the corresponding courses for which credit is requested.

The Graduate Committee will decide what credits will be accepted. If the courses were taken at another university, at most one third (1/3) of the credits required for a graduate degree can be accepted. The students must take all the other courses required by the Department of Mathematics for the Ph.D. degree, including those approved by the Graduate Committee to substitute the ones used for a previous degree at the same level or at the undergraduate level. They must meet all other requirements of the Department of Mathematics for obtaining the Ph.D. degree.

B. PLACEMENT EXAMINATIONS

After students are accepted to the Graduate Program, they have to take a Placement Examination, which has the aim of determining any deficiencies in their preparation in two basics areas of mathematics:

a. Mathematical Analysis (Advanced Calculus), including Advanced Calculus of Several Variables, and

b. Modern Algebra, including Linear Algebra.

Accordingly, the Placement Examination will have two parts, to be administered twice yearly during the same week but not during the same day.

The aim of these examinations is to verify the adequacy of preparation of the students in these two fundamental branches of mathematics, even if they have already taken the corresponding courses at the undergraduate level.

The students who have not taken

a'. the equivalent of 6 credits of Advanced Calculus, at the undergraduate level, including Advanced Calculus of Several Variables, and

b'. the equivalent of 9 credits of Modern Algebra, at the undergraduate level, including Linear Algebra,

or have taken these courses but fail any part of the Placement Examination, will be requested to take the corresponding two-semester pre-graduate course (MATH 5101-5102, MATH 5301-5302). To qualify for the Ph.D. degree, the students are required to pass each part of the Placement Examination, and will have three opportunities to do so in a period of time not to exceed two years after entering the graduate program, or pass the corresponding pre-graduate course with a grade of "B" or better. Failing to take and pass the pre-graduate courses and the Placement Examination does not preclude the students from completing the requirements for the M.S. degree.

C. GRADE POINT AVERAGE

The students must obtain a grade of "B" or better in all courses taken in the first year. In general, the students must maintain an average of "B" or better in all courses taken. Courses with grades of "D" and "F" cannot be used to fulfill degree requirements. Any grade of incomplete in a course must be removed.

IV. ADVISING, COURSE PROGRAM, SEMINARS, AND MAINTENANCE OF GRADUATE STANDING

The Department offers specialization in two fields of mathematics in the M.S. program:

1. Pure Mathematics
2. Applied Mathematics

The Department offers specialization in three fields of mathematics in the Ph.D. program:

1. Pure Mathematics
2. Discrete Mathematics
3. Computational Mathematics

Every student is expected to meet with an academic advisor each semester. Upon admission, new students should contact the Office of Graduate Studies of the Department of Mathematics to make arrangements for advising. They are expected to make their choice of the field of specialization. This can be changed at the end of the first year of study, provided the student takes the required courses for the new specialization field.

A. FIRST YEAR M.S. PROGRAM

During the first year the students are expected to take a series of core courses that will constitute the basis for more advanced work. The core courses are divided according to the option in the master's program as follows:

1. Pure Mathematics
   a. Modern Algebra I & II (MATH 6201-6202)
   b. Real Analysis I & II (MATH 6261-6262)
   c. General Topology, Algebraic Topology (MATH 6540-6551)

d. Complex Analysis I (MATH 6301)

The students must complete a minimum of a one-year course sequence in either Analysis (MATH 6261-6262), Algebra (MATH 6201-6202), or Topology (MATH 6540-6551). It is highly recommended that at least two of these course sequences be completed.

2. Applied Mathematics

a. Probability & Statistics I & II (MATH 6601-6602)

b. Data Structures I & II (MATH 6681-6682)

c. Computational Analysis, Linear or Non-Linear Programming (MATH 6680-6881 or 6882)

The students must complete a minimum of a one-year course sequence in either Probability and Statistics (MATH 6601-6602), Data Structures (MATH 6681-6682), or Computational Analysis and Optimization (MATH 6680-6881 or 6882). It is highly recommended that at least two of these course sequences be completed.

B. SECOND YEAR M.S. PROGRAM

Courses at the 6000 and 8000 level in mathematics carry graduate credit. Not more than three credits in independent studies (MATH 6990) will be accepted towards the M.S. degree. Electives are used primarily to develop background and maturity for the thesis.

C. THIRD YEAR M.S. PROGRAM

A three-credit graduate seminar MATH 6800 is required of the students in the Pure Mathematics option. A three-credit Project in Applied Mathematics seminar MATH 6700 is required of the students in the Applied Mathematics option. A thesis is required for the M.S. degree. A student may register for three credits in Master's Thesis (MATH 6996) after having passed the written qualifying examinations at the master's level.

D. FIRST YEAR Ph.D. PROGRAM

During the first year of graduate studies in the Ph.D. program, the students in all three specialization fields will take 15 credits in "common core courses" and 3 credits in courses specific to the chosen specialization as follows:

1. Pure Mathematics

First Semester

a. Modern Algebra I (MATH 6201) (3 credits)

b. Real Analysis I (MATH 6261) (3 credits)

c. Linear Algebra (MATH 6150) (3 credits)

Second Semester

a. Modern Algebra II (MATH 6202) (3 credits)

b. Complex Analysis I (MATH 6301) (3 credits)

c. General Topology (MATH 6540) (3 credits)

2. Discrete Mathematics

First Semester

a. Modern Algebra I (MATH 6201) (3 credits)

b. Real Analysis I (MATH 6261) (3 credits)

c. Linear Algebra (MATH 6150) (3 credits)

Second Semester

a. Modern Algebra II (MATH 6202) (3 credits)

b. Complex Analysis I (MATH 6301) (3 credits)

c. Graph Theory I (MATH 8001) (3 credits)

3. Computational Mathematics

First Semester

a. Modern Algebra I (MATH 6201) (3 credits)

b. Real Analysis I (MATH 6261) (3 credits)

c. Linear Algebra (MATH 6150) (3 credits)

Second Semester

a. Modern Algebra II (MATH 6202) (3 credits)

b. Complex Analysis I (MATH 6301) (3 credits)

c. Computational Analysis I (MATH 6680) (3 credits)

The recommended distribution of courses in subsequent years is described in the sequel.

E. SECOND YEAR Ph.D. PROGRAM

1. Pure Mathematics

First Semester

a. Mathematical Analysis I (MATH 6271) (3 credits)

b. Complex Analysis II (MATH 8309) (3 credits)

c. Algebraic Topology (MATH 6551) (3 credits)

Second Semester

a. Mathematical Analysis II (MATH 6272) (3 credits)

b. Real Analysis II (MATH 6262) (3 credits)

c. Functional Analysis I (MATH 6460) (3 credits)

2. Discrete Mathematics

First Semester

a. Linear Programming (MATH 6881) (3 credits)

b. Enumerative Combinatorics (MATH 8005) (3 credits)

c. Discrete Algorithms (MATH 8015) (3 credits)

Second Semester

a. Convex Polytopes (MATH 8051) (3 credits)

b. Algebraic Combinatorics I (MATH 8021) (3 credits)

c. Combinatorial Optimization I (MATH 8031) (3 credits)

3. Computational Mathematics

First Semester

a. Mathematical Analysis I (MATH 6271) (3 credits)

b. Data Structures I (MATH 6681) (3 credits)

c. Probability and Statistics I (MATH 6601) (3 credits)

Second Semester

a. Mathematical Analysis II (MATH 6272) (3 credits)

b. Data Structures II (MATH 6682) (3 credits)

c. Probability and Statistics II (MATH 6602) (3 credits)

F. THIRD YEAR Ph.D. PROGRAM

1. Pure Mathematics

First Semester

a. Functional Analysis II (MATH 8469) (3 credits)

b. Topics (3 credits)

c. Topics (3 credits)

Second Semester

a. Spectral Theory and Differential (3 credits)
Equations (MATH 8465)

b. Topics (3 credits)

c. Topics (3 credits)

2. Discrete Mathematics

First Semester

a. Applied Algebra I (MATH 6656) (3 credits)

b. Matroid Theory (MATH 8041) (3 credits)

c. Topics (3 credits)

Second Semester

a. Topics (3 credits)

b. Topics (3 credits)

c. Topics (3 credits)

3. Computational Mathematics

First Semester

a. Computational Analysis II (MATH 6690) (3 credits)

b. Topics (3 credits)

c. Topics (3 credits)

Second Semester

a. Topics (3 credits)

b. Topics (3 credits)

c. Topics (3 credits)

The topic courses in each specialty area for the first three years in the Ph.D. program must belong to a list approved by the Graduate Committee. New topic courses may be recommended for approval if they are submitted to the Graduate Committee in the proper format, including title, prerequisites, course description, objectives, course syllabus with time

distribution, instructional strategies, grade evaluation, bibliography and references. Each topic course is worth three credits and graded pass/fail. Once the topic course is approved, it will be assigned a codification (MATH 8985, MATH 8986, MATH 8995, and section number if applicable) by the Graduate Committee and included in the list of approved topic courses.

The level and contents of the courses are determined by the bibliographies listed in the textbooks. The professors are encouraged to bring the courses up-to-date, including new results and improvements in the presentation of the material.

The students are required to develop the ability to do mathematical research. This can be best achieved by working out as many exercises and problems as possible from the recommended textbooks and, at a higher level, by studying research papers in the fields chosen by the students. The presentation of such papers in seminars will bring the students to the threshold of contemporary research. To this end, beginning with the third year, all students seeking a degree must register for three credits in a master's seminar (either MATH 6800 or MATH 6700). Beginning with the fourth year, the students aiming at the Ph.D. degree will take part in research seminars offered by the Department of Mathematics in three areas: Pure Mathematics, Discrete Mathematics, and Computational Mathematics. The students seeking the Ph.D. degree are required to register for three credits in a doctoral seminar.

Students are expected to make steady progress toward their degrees. For the M.S. degree, all requirements must be completed within five years from the date of admission. A student interested in obtaining the Ph.D. degree must be admitted to candidacy within four years from the date of admission to the graduate program. All requirements for the Ph.D. degree must be completed within eight years from the date of admission. Exceptional cases

for an extension that cannot exceed two years will be considered by the Graduate Committee to complete the requirements for a degree.

Any course may be repeated only one more time and the better grade is used in determining the average. An average of "B" is required at the time of obtaining a degree, but courses with grades of "D" and "F" cannot be used to fulfill degree requirements.

V. QUALIFIFYING EXAMINATIONS

The students interested in qualifying for the Ph.D. degree must take written qualifying examinations in three fields of mathematics. These are

1. Mathematical Analysis, split into
    a. Real Analysis and
    b. Complex Analysis,

    based on the material of the core courses of the first year of study.
2. Algebra, split into
    a. Modern Algebra and
    b. Linear Algebra,

    based on the material of the core courses of the first year of study.
3. An examination specific to the chosen option based on the material of a one-semester specialization course of the first year (second semester), second year, and/or third year (first semester) of study. According to the chosen option, the examinations will be given in the following fields:
    a. The Pure Mathematics option: Topology, Algebraic Topology, Mathematical Analysis I, Mathematical Analysis II, Real Analysis II, Complex Analysis II, Functional Analysis I, Functional Analysis II.

b. The Discrete Mathematics option: Graph Theory I, Linear Programming, Applied Algebra I, Enumerative Combinatorics I, Discrete Algorithms, Combinatorial Optimization I, Convex Polytopes, Algebraic Combinatorics I, Matroid Theory I.

c. The Computational Mathematics option: Mathematical Analysis I, Mathematical Analysis II, Probability and Statistics I, Probability and Statistics II, Data Structures I, Data Structures II, Computational Analysis I, Computational Analysis II.

Detailed syllabi may be requested in the Office of Graduate Studies of the Department of Mathematics.

The students interested in qualifying for the M.S. degree have two options:

a. They may take the same examinations that are administered to Ph.D. students, and may receive a master's level pass (if unsuccessful at the doctoral level). These students have three consecutive opportunities to pass three exams at the master's level.

b. They may take the master's qualifying examinations, that will test basic knowledge in several general areas determined by the Pure or Applied Mathematics option chosen in the M.S. program.

   Pure Mathematics

   i. Algebra (MATH 6201)

   ii. Real Analysis (MATH 6261)

   iii. Complex Analysis (MATH 6301)

   iv. Topology (MATH 6540)

Applied Mathematics

i. Probability and Statistics I (MATH 6601), Probability and Statistics II (MATH 6602)
ii. Computational Analysis (MATH 6680), Linear Programming (MATH 6881), Non-Linear Programming (MATH 6882)
iii. Data Structures I (MATH 6681), Data Structures II (MATH 6682)

Pure Mathematics students admitted to the graduate program on or after the second semester 2005-2006 have three consecutive opportunities to pass three exams, two in areas (i, ii, iii, iv) in Pure Mathematics, plus one free elective in any of the above areas, Pure or Applied.

Applied Mathematics students admitted to the graduate program on or after the second semester 2005-2006 have three consecutive opportunities to pass three exams, two chosen from different areas (i, ii, iii) in Applied Mathematics, plus one free elective in any of the above areas, Pure or Applied.

The examinations will test the level of understanding of the basic material discussed in the core courses required for the M.S. degree. The syllabi for these examinations may be requested in the Office of Graduate Studies of the Department of Mathematics. To be allowed to take the master's qualifying examinations, a student must have a grade point average of at least 3.00, and must have completed all the core courses in one of the options of the M.S. program.

The written qualifying examinations will be offered twice yearly. Regular students in the M.S. program must take the qualifying examinations as soon as possible but no later than the fourth semester of graduate studies. Regular students in the Ph.D. program must take

the qualifying examinations beginning no later than the fifth semester of graduate studies. There is no limit on the number of times a student can attempt the examinations that are administered to students interested in qualifying for the Ph.D. degree, but in order to earn a degree the examinations must be passed by the end of the student's third year in the graduate program.

All doctoral candidates must take in addition an oral examination for advancement to the Ph.D. candidacy. This can only be taken after the student has passed the written qualifying examinations at the Ph.D. level. The oral examination will test the breath and depth of the student's knowledge in his/her field of interest, and will be taken as evidence of the student's preparedness to do research and write a doctoral dissertation. The oral examination committee will consist of three faculty members, specialists in the field of interest of the student. All doctoral candidates must pass the oral examination for advancement to the Ph.D. candidacy by the end of their fourth year in the graduate program.

VI. REQUIREMENTS APPLICABLE TO M.S. CANDIDATES

A. COURSE REQUIREMENTS

The students aiming at the M.S. degree will be required to take at least 30 credits in courses:

1. 12 credits for the core courses of the first year.
    a. The Pure Mathematics option core courses involve work in four main areas: Algebra (MATH 6201), Real Analysis (MATH 6261), Topology (MATH 6540), and Complex Analysis (MATH 6301).
    b. The Applied Mathematics option include courses in Probability and Statistics (MATH 6601), Data Structures (MATH 6681), Computational Analysis

(MATH 6680) or Optimization (Linear Programming (MATH 6881) or Non-Linear Programming (MATH 6882)), and must include at least one other graduate level course in order to complete a minimum of one of the following year sequences: MATH 6601-6602, MATH 6681-6682, MATH 6680-6881 or 6882.

2. 12 credits in electives.

Courses at the 6000 and 8000 level in mathematics (except MATH 6685) carry graduate credit. Not more than three credits in independent studies (MATH 6990) will be accepted towards the M.S. degree.

a. In the Pure Mathematics option, it is required that a minimum of a one-year course sequence in either Analysis (MATH 6261-6262), Algebra (MATH 6201-6202), or Topology (MATH 6540-6551) be completed; hence three credits must be chosen in either MATH 6262, MATH 6202 or MATH 6551. It is highly recommended that students take at least two of these course sequences.

b. In the Applied Mathematics option, it is highly recommended that students complete at least two of the following course sequences: MATH 6601-6602, MATH 6681-6682, MATH 6680-6881 or 6882.

3. 3 credits in a master's seminar

a. Pure Mathematics option: MATH 6800

b. Applied Mathematics option: MATH 6700

4. 3 credits in Master's Thesis (MATH 6996)

B. MASTER'S SEMINAR

Beginning with the third year, the students should take part in seminars offered by the Department of Mathematics. Each seminar will meet three hours each week.

All students seeking a degree will be required to register for three credits in a master's seminar. Students in the Pure Mathematics option of the M.S. program must register in MATH 6800. Students in the Applied Mathematics option of the M.S. program must register in MATH 6700.

The seminars at this level will have a more elementary character, being dedicated to the presentation and solution of the problems from the textbooks used during the first two years, and/or the presentation of the results of some research work or project in pure or applied mathematics.

Participation in one of these seminars is required also of the students who wish to be admitted to candidacy for the Ph.D. degree.

C. M.S. THESIS

After having passed the written qualifying examinations, described in Section V, the student will begin the apprenticeship in doing research and the documentation for the M.S. thesis if the student aims at the M.S. degree.

The student must obtain the consent of a faculty member who will accept the responsibility of directing the thesis. This person will be the "thesis advisor" of the student, and will become his academic advisor, replacing the one mentioned in Section IV.

The M.S. thesis should represent a meaningful piece of original and independent work, which has some novel features; for example, the detailed working out of the application of a general theory or method to some particular case or cases of interest. A significant original contribution to the field is not deemed necessary.

The minimum level of the M.S. thesis should be that of a scholarly paper of an expository nature, related to the courses the student has taken. The scholarly paper should be based on substantial use of at least two sources, one of which should be a journal article, with appropriate references given.

The M.S. thesis will be defended in a final oral examination. Each member of the final oral examination committee must receive a legible typed copy of the thesis at least one month before the final oral examination.

The final oral examination committee will consist of three members, including the advisor. The members of the committee should be specialists in the field in which the thesis is written.

The examination is open to the public. The student will be examined on the thesis and related topics, at the discretion of the examiners.

A copy of the thesis must be available in the Library of the Faculty of Natural Sciences to the public at least one month before the final oral defense examination.

VII. REQUIREMENTS APPLICABLE TO PH.D. CANDIDATES

The purpose of the doctoral program of the Department of Mathematics is to prepare specialists capable of doing research and creative, independent, original work in the fields of mathematics represented by the three options.

To obtain the Ph.D. degree in mathematics, a student must display a high level of scholarship shown by the ability to do original research and should possess a broad knowledge of the major fields of modern mathematics. It is not necessary to have a master's degree before obtaining the doctorate.

A. MINIMUM REQUIREMENTS

In order to obtain a Ph.D. degree, the student must have:

1. Passed all the courses for the first three years, a total of 54 credits, with an average of "B" or better, plus courses related to the subject of the Ph.D. dissertation.

2. Taken 15 additional credits as follows:

   a. 3 credits in a master's seminar (MATH 6700 or MATH 6800)

   b. 3 credits in a doctoral seminar (MATH 8800)

   c. 3 credits in Doctoral Dissertation (MATH 8991)

   d. 6 credits in courses related to the subject of the doctoral dissertation; these can be "independent study" courses.

      Courses used as part of the master's program may be used in fulfillment of this requirement.

      Courses with grades of "D" and "F" cannot be used to fulfill degree requirements.

3. Passed the written qualifying examinations at the doctoral level in three fields as described in Section V.

4. Fulfilled such specific requirements set forth by the option committee that represents the student's principal mathematical interests, in order to obtain sufficient evidence of depth of mathematical knowledge and ability to write a dissertation on a topic in the field in question. The details of these requirements can be obtained from the Office of Graduate Studies of the Department of Mathematics.

5. Passed the oral examination for advancement to the Ph.D. candidacy.

6. Been admitted to candidacy.

B. ADMISSION TO CANDIDACY

Before petitioning for admission to candidacy, a student must have:

1. Demonstrated a competent knowledge of Spanish and English. A reading knowledge of French, German, or Russian is strongly recommended.
2. Maintained a "B" average or better in formal course work, with grades of "B" or better in the courses related to the chosen option.
3. Passed the written qualifying examinations at the doctoral level, as described in Section V.
4. Passed the oral examination for advancement to the Ph.D. candidacy.
5. Satisfied the specific requirements of the option committee governing the field of principal interest.
6. Obtained the consent of a faculty member who will accept the responsibility of directing a dissertation.

C. PH.D. DISSERTATION

1. The dissertation prepared must represent a substantial, original, and independent contribution of the student to existing mathematical knowledge. The following statement is quoted from the official document "Certificada con acuse de recibo número 7099 3400 0005 3314 04 95 del Consejo de Educación Superior de Puerto Rico", dated September 26, 2000, and addressed to the President of the University of Puerto Rico:

   " . . . Dada la circunstancia particular de que un programa de Ph.D. es diferente a un doctorado profesional porque va dirigido a preparar personas dedicadas a la investigación científica (eruditos), es necesario tener en mente que los egresados de este programa deben hacer una contribución al saber humano".

2. The Ph.D. dissertation must be defended in an oral examination, in front of a final oral examining committee consisting of five members, at least one of whom must belong to the graduate faculty of the department of mathematics of another university. All members of the committee must be specialists in the field of the dissertation. Each member of the committee must receive a copy of the dissertation at least one month before the final oral defense examination, which must be public, possibly preceded by a private defense. Also, at least one month in advance, a copy of the dissertation must be made available in the Library of the Faculty of Natural Sciences to the public.

3. When a copy of the dissertation is submitted to each member of the examining committee, a copy of at least one paper based on the student's research work related to the subject of the dissertation must also be submitted. This paper must be published in a "peer-review" mathematical journal, or accepted for publication in such a journal. This rule can be ignored only in special cases with the unanimous approval of the examining committee, but will not exempt the student, however, of the obligation to submit such a paper for publication.

4. The final oral examining committee will examine the candidate on the research work incorporated in the dissertation, review preparation in the fields related to it, and then vote on the candidate's qualifications for the degree. In order to justify a finding of failure, at least two negative votes must be cast.

VIII. THE GRADUATE COMMITTEE

1. The Graduate Committee consists of 6 professors (2 for each option in the doctoral program, to be chosen with a majority of votes), the Coordinator of the Graduate

Program, and the Chairman of the Department (the latter two are ex officio members).

The tasks of the Committee include

a. to admit the students to the Graduate Program on an individual basis, in accordance with the established rules.

b. to recommend to the Chairman of the Department the awarding and renewal of teaching assistantships.

c. to fix the dates of the examinations, in accordance with the general schedule of the Department.

d. to appoint the oral examination committees, for the defense of the M.S. theses and the Ph.D. dissertations. These appointments will be made on the basis of the recommendations of the thesis advisor and the two members of the Graduate Committee representing the option chosen by the student.

e. to decide on the termination of the admission status of a student if and when the overall performance is below expectation.

f. to evaluate the exceptional cases and submit the decisions and recommendations to the appropriate university administrative offices. Some exceptional cases should be decided on the basis of the unanimous approval of the Graduate Committee. In general, at most two negative votes are compatible with the exceptional status.

g. to recommend to the Department, for approval, any changes in the curriculum deemed as being necessary for the improvement of the preparation of the students.

2. The Graduate Committee will be presided by the Coordinator of the Graduate Program. The Coordinator will be appointed by the Chairman upon recommendation of the 6 professors representing the three options. The chosen Coordinator can be one of these 6 professors.

APPENDIX: REFERENCES FOR THE FIRST YEAR CORE COURSES

The Modern Algebra (I & II) course will include material found in the following textbooks:

i. S. Lang, *Algebra*,

ii. B.L. Van der Waerden, *Algebra*,

iii. T. Martin Isaacs, *Algebra: A Graduate Course*,

iv. D. Dummit, R. Foote, B. Holland, *Abstract Algebra*,

v. S. Mac Lane, G. Birkhoff, *Algebra*,

vi. N. Jacobson, *Basic Algebra, vol. I, II*.

The Real Analysis I course will include material found in the following textbooks:

i. H.L. Royden, *Real Analysis*,

ii. Ch. D. Aliprantis, O. Burkinshaw, *Principles of Real Analysis*,

iii. S. Lang, *Real and Functional Analysis*,

iv. E.M. Lieb, M. Loss, *Analysis*,

v. P. Malliavin, *Integration and Probability*,

vi. A.M. Bruckner, J.B. Bruckner, B.S. Thomson, *Real Analysis*.

The Complex Analysis I course will include material found in the following textbooks:

i. J.B. Conway, *Functions of One Complex Variable*,

ii. E. Hille, *Analytic Function Theory*,

iii. L. Ahlfors, *Complex Analysis*,

iv. W. Rudin, *Real and Complex Analysis* (this textbook is recommended also for the Real Analysis I course),

v. R.B. Burckel, *An Introduction to Classical Complex Analysis*,

vi. A.J. Markushevich, *Theory of Functions of a Complex Variable*.

The Linear Algebra course will include material found in the following textbooks:

i. Ichiro Satake, *Linear Algebra*,

i. P.R. Halmos, *Finite-Dimensional Vector Spaces*,

ii. K. Hoffman, R. Kunze, *Linear Algebra*,

iii. W. Nef, *Linear Algebra*,

iv. G.E. Shilov, *Linear Algebra*.