Mathematical Modeling

Graduate Student Handbook

Ph.D. Program in Mathematical Modeling

School of Mathematical Sciences

2018-2019

R·I·T College of SCIENCE

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Program Overview

Mathematical modeling is the process of developing mathematical descriptions of real-world systems that are used to understand and to predict phenomena. Many current problems in science and technology are of such size and complexity that their solutions require sophisticated techniques drawn from computational and applied mathematics as well as the participation of mathematicians in the interdisciplinary teams of scientists that address them. The Ph.D. program in Mathematical Modeling trains students to become experts in formulating complex problems mathematically, integrating data with models, devising and implementing algorithms, analyzing and interpreting solutions, and communicating effectively with experts in various fields.

Courses and Curriculum

The degree requires at least 60 credit hours of course work and research. The curriculum consists of three required Core courses, three required Concentration Foundation courses, a course in scientific computing and high-performance computing, three elective courses focused on the student's chosen research concentration, and a doctoral dissertation. A minimum of 30 credit hours of course work is required. In addition to courses, at least 30 credit hours of research, including the Graduate Research Seminar, are required.

Course Requirements

The core courses provide necessary background and foundational material and introduce students to some of the general tools of mathematical modeling and applied and computational mathematics. The concentration courses bring together in a mathematically unified manner the ideas in an area of interest to each student. Elective courses for the mathematical modeling program are available from within the School of Mathematical Sciences as well as from other graduate programs at RIT, which can provide application-specific courses of interest for particular research projects.

Core Courses

Each student must take three **Core Courses**, for a total of 9 semester credit hours. These courses usually are taken in the first year of study and provide students with a focus on some of the main principles of mathematical modeling. Core courses are offered every year. The following are the three core courses along with the semesters they are offered.

MATH-602	Numerical Analysis I	Fall
MATH-622	Mathematical Modeling I	Fall
MATH-722	Mathematical Modeling II	Spring

Concentration Foundation Courses

In addition to the Core courses, each student must complete an additional 9 semester credit hours as **Concentration Foundation Courses** by choosing to take a pre-defined set of three specialized courses from a variety of courses offered in the School of Mathematical Sciences and other academic units.

Each set of concentration courses forms a well-defined and meaningful focus area of study. The

concentration should be chosen to provide the necessary mathematical background and tools to address modeling problems related to each student's interests. Ideally, the concentration is chosen to inform each student's dissertation. The concentrations and associated courses are listed below.

Concentration	Course	Semester offered	Graduate prerequisites
Applied inverse problems	Measure Theory and Elements of Functional Analysis (MATH-633)	Fall	None
	Partial Differential Equations I (MATH-741)	Spring	None
	Applied Inverse Problems (MATH-821)	Fall	MATH-633
Biomedical mathematics	Dynamical Systems (MATH-631)	Fall	None
	Mathematical Biology (MATH-761)	Fall	None
	Numerical Analysis II (MATH-702)	Spring	MATH-602
Discrete mathematics	Graph Theory (MATH-645)	Fall	None
	Combinatorics (MATH-646)	Spring	None
	Foundations of Algorithms (CSCI-665)	Fall, Spring	Permission of instructor
Dynamical systems and fluid dynamics	Dynamical Systems (MATH-631)	Fall	None
	Partial Differential Equations I (MATH-741)	Spring	None
	Mathematical Fluid Dynamics (MATH-831)	Fall	MATH-741
Geometry, relativity and gravitation	Introduction to Relativity and Gravitation (ASTP-760)	Fall	None
	Advanced Relativity and Gravitation (ASTP-861)	Spring	ASTP-760
	Numerical Analysis II (MATH-702)	Spring	MATH-602

Elective Courses

In addition to the Core courses and Concentration Foundation courses, each student must complete 9 semester credit hours as **Electives**. Electives are required to develop students' specialties and to complete their preparation for dissertation research. These courses are chosen based on each student's application domain knowledge and background within a plan of study. Any graduate-level course approved for the student's plan of study can count as an elective. Students are encouraged to take some elective courses in the application fields relevant to their research interests. Outlines for SMS graduate courses are listed at https://www.rit.edu/science/sms/courses; a full list of RIT graduate courses is available at https://www.rit.edu/upub/pdfs/Graduate_Course_Descriptions.pdf.

High-performance Computing Course

Students also must take at least one semester of a course focused on scientific computing and high-

performance computing (HPC) to gain skills needed to solve computationally intensive problems. A special-topics course on high-performance computing with applications to solving problems formulated using mathematics will be offered in Spring 2019.

Other courses may be selected to satisfy this requirement. Examples of other suitable courses are listed below.

CSCI-654 Foundations of Parallel Computing
CSCI-652 Distributed Systems
CSCI-714 Scientific Visualization
CMPE-655 Multiple Processor Systems
CMPE-750 Advanced Computer Architecture
CMPE-755 High Performance Architectures.

It is expected that the above list will change as new graduate-level HPC courses are developed and offered throughout RIT. Students wishing to satisfy the HPC requirement through the course that is not the special-topics course and is not a course on the list should obtain approval from the Program Director prior to enrolling.

Graduate Seminar

Students are required to take the two-course sequence of graduate seminar classes, MATH-606 and MATH-607 (Graduate Seminar I and II). These courses introduce students to the variety of research being carried by Mathematical Modeling faculty and teach various research skills that will help students be successful in carrying out dissertation research and in writing and defending the dissertation. MATH-606 and MATH-607 should be taken during the first year of graduate studies.

Program of Study

Individual Plan of Study

Students develop a plan of study in consultation with an Application Domain Advisory Committee consisting of the Program Director, one of the concentration faculty leads, and an expert from an application domain related to the student's research interest. The plan of study specifies all courses the student will take to satisfy the degree requirements and will be informed by the student's background and research interests. It also suggests appropriate timing for satisfying the program's interdisciplinary internship requirement. The Application Domain Advisory Committee approves the plan of study before the end of the student's first semester in the program. The plan of study may be revised as needed, subject to the approval of the Application Domain Advisory Committee.

Students should not register for courses not included in their approved plans of study. If changes are desired, these must be discussed and approved by the Application Domain Advisory Committee.

First Year of Graduate Study

The following is a guideline of coursework to complete during the first year of study. Note that alternatives are possible depending on courses selected to satisfy the core, concentration, and elective

course requirements.

Fall:	MATH-602 Numerical Analysis I MATH-606 Graduate Seminar I MATH-622 Mathematical Modeling I Concentration Foundation Course I
Spring:	MATH-607 Graduate Seminar I MATH-722 Mathematical Modeling II Concentration Foundation Course II Elective Course I OR High-performance Computing Course

Course Administration

Policies regarding course registration, withdrawal, and repetition; grades needed for program credit; transfer credit; and full-time equivalency are given below.

Course Registration

Students are responsible for registering for courses. Online registration via the **Student Information System (SIS)** (http://sis.rit.edu) is available toward the end of each preceding semester; first-year students should register for courses by late June or early July whenever possible. The Program Assistant can help first-year students with any issues associated with registering for approved courses. For the first semester, students should discuss planned courses with the Program Director before enrolling. For subsequent semesters, students should register only for courses included in their approved plans of study. Any desired changes must be discussed and approved by the Application Domain Advisory Committee prior to registration.

Course Withdrawal

Students should discuss any course withdrawal with the Program Director before withdrawing. If a student withdraws from a course during the Add/Drop period specified in RIT's Academic Calendar, the course will not be listed on the student's semester grade report or permanent record. After the Add/Drop period is over, courses dropped will appear on the semester grade report and will remain on the student's permanent record. If the course is dropped no later than the last day to drop from classes with a grade of "W" as specified in RIT's Academic Calendar (typically Friday of the 11th week of classes), the course will appear with a grade of "W". After this date it is not possible to withdraw from a course except in extraordinary circumstances that should be discussed with the Program Director.

Minimum Course Grade to Satisfy a Program Requirement

Per RIT policy, students must attain a grade of C or higher for the course to count as satisfying a program requirement. Thus, courses where a grade of C- or lower is earned cannot be used to satisfy a requirement of the program. However, the course grade is included in calculating grade point average (GPA). If the course is mandatory, it must be repeated, as described below. For more information on RIT's grade policies, see https://www.rit.edu/academicaffairs/policiesmanual/d050.

Repeating a Course

Per RIT policy, for graduate students, approval from the dean or dean's designee of the student's home academic unit is required for any graduate courses a student wishes to take a second time.

If permission to take a course a second time is granted, the grades of all courses attempted count in calculating the program cumulative GPA. In addition, a graduate program GPA manually calculated by the academic unit is used for degree certification and must be at least 3.0 ("B" average) as a graduation requirement. All academic program course attempts are included in this calculation. See https://www.rit.edu/academicaffairs/policiesmanual/d050.

Graduate Probation and Suspension

Any matriculated graduate student whose program cumulative GPA falls below a 3.0 ("B" average) at any time after completing at least 9 semester credit hours (excluding MATH-606 and MATH-607) is placed on probation and counseled by the Program Director. These students are required to raise their program cumulative GPA to the 3.0 level within the next 9 semester credit hours (excluding MATH-606 and MATH-607); otherwise, they are suspended from the graduate program.

Any suspended student may apply to the Program Director for readmission and may be readmitted upon demonstration of sufficient and valid reason for readmission. The decision to readmit a student on probation or suspension is made by the Head of the School of Mathematical Sciences.

Applying Previous Graduate Course Credits

At the discretion of the Program Director, graduate-level coursework completed at another institution or taken in another RIT graduate program may be transferred and applied toward the Ph.D. degree in Mathematical Modeling. Approved transferred coursework is included in the student's plan of study, which indicates the specific requirements transferred courses are deemed to satisfy. Such classes must be listed on the plan of study as they appear on the other school's transcript, using that school's numbering (if any), course name, credit hours (in semesters), and grade awarded. Pass/fail courses may not be used to satisfy course requirements.

Transfer credit for any coursework earned before matriculating in the Mathematical Modeling Ph.D. program should be requested through application to the Program Director during the first year. Graduate courses taken at RIT before enrolling in the Ph.D. program can be transferred in the same manner. Courses taken at other institutions after beginning the Ph.D. program can be transferred only if included in the student's plan of study approved by the Application Domain Advisory Committee prior to taking any such courses.

Transfer credit is subject to RIT policies limiting the total number of credit hours that can be transferred.

Full-time Equivalency

RIT considers graduate-level students to be full-time in every academic term in which they are enrolled for at least 9 credit hours. With approval of the Program Director, a full-time equivalency can be granted for such activities as dissertation research, research or teaching assistantships, and

internships. Full-time equivalency normally should be sought any semester in which the total of registered course credits and thesis credits is less than nine.

Dissertation Research Credits

In addition to courses, each student must complete at least 30 credit hours of dissertation research. The Graduate Research Seminar courses count toward satisfying this requirement. For the remaining credit hours, the student should initiate the registration process for the associated dissertation research credit course (MATH-790) each semester as needed by providing the Program Assistant with the name of the research supervisor, typically the Second-year Project or Dissertation Advisor, by email. While enrolled in these credits, students work closely with their Second-year Project or Dissertation Advisor on the mathematical problems of their choice.

Research credits are given grades of “R” (registered) or “U” (unsatisfactory). Grades of “U” are given if the Second-year Project or Dissertation Advisor indicates that satisfactory progress has not been made; in these cases, research credits carrying “U” grades must be repeated.

Continuation

Students must maintain continuous enrollment while they are working on their dissertation research. Such enrollment is not limited by the program’s research credit requirement. When a student has completed all coursework as well as the minimum required dissertation research credits but has not yet successfully completed the Dissertation Defense and submitted the dissertation to ProQuest, the student must enroll in a zero-credit Continuation of Thesis (MATH-791) course for subsequent terms (not including summer terms). Continuation of Thesis allows the student to maintain access to campus resources, such as the Wallace Center. Continuation of Thesis carries a tuition fee equivalent to one credit, but this fee is waived by SMS for the first term of Continuation of Thesis enrollment. In subsequent terms, the Continuation of Thesis fee must be paid by the student. A student who fails to enroll for Continuation of Thesis when required will be automatically withdrawn from the program. For complete details of the Continuation of Thesis policy, see https://www.rit.edu/academicaffairs/policiesmanual/d120.

Other Program Elements

Interdisciplinary Internship

In addition to the coursework, each student is required to have an interdisciplinary internship outside RIT in an application domain of mathematical modeling. This experience helps students develop contacts with industry and is likely to provide opportunities for job placement. Internships can include working for a summer or semester in industry or at a government lab and can provide opportunities for paid employment for students during the summer when not supported by a Research Assistantship. Cooperative education experiences are an excellent option.

Interdisciplinary internships must be approved in advance by the Program Director in order to satisfy the program requirement. Typically internships will involve at least 10 weeks of full-time work or the equivalent.

Internship Timing

Students can satisfy the interdisciplinary internship requirement at any time during their program of study. There are advantages associated with different timing options.

- ***First summer:*** Obtaining an internship for the first summer can provide a meaningful research experience early in the program of study and can make the student aware of different avenues of research.
- ***Middle of the program:*** During the middle of the program, an internship can help a student gain valuable industry experience, which may help with career choices.
- ***Late in the program:*** Satisfying the internship requirement within a year of the dissertation defense may lead directly to post-graduation job opportunities.

Students should discuss internship options with the Application Domain Advisory Committee and, if necessary after all coursework has been completed, with the Dissertation Advisor and Program Director. Regardless of when the internship is planned, students are encouraged to plan ahead and to develop strategies for finding internships 6-12 months in advance of the planned time.

Students may complete multiple summer internships if not supported through Research Assistantships, but only one approved internship is needed to satisfy the requirement. Any student wishing to engage in more than one non-summer (Fall or Spring) internship must obtain prior approval; internship completion should not significantly lengthen time to degree.

Resources for Finding Internships

Interdisciplinary internships may be found in many different ways. The Office of Career Services and Cooperative Education at RIT (https://www.rit.edu/emcs/oce/) is a valuable resource. In addition, the Application Domain Advisory Committee, Dissertation Advisor, Program Director, and Mathematical Modeling faculty serve as additional resources for students. Students begin learning skills for marketing themselves as part of the first-year Graduate Seminar courses.

Please contact Kris Stehler, Career Services Coordinator (475-5468, kwsoce@rit.edu) for more information about co-op.

Cooperative Education

Students may engage in a Cooperative Education experience to satisfy their Interdisciplinary Internship requirement. International students normally are limited to one Cooperative Education experience; if additional Cooperative Education experiences are desired, these students should obtain prior approval from the Program Director. Cooperative education should not serve to lengthen the time to degree significantly and must adhere to immigration policies.

Ph.D. Advising

Students have several advisors and advisory committees throughout the program.

Academic Advisor

Upon admission into the program, the student is assigned an Academic Advisor. By default, each student's Academic Advisor is the Program Director. Upon request, a new Academic Advisor can be assigned at the discretion of the Program Director. The role of the Academic Advisor is to help answer any questions and address any concerns the student may have about the program, coursework, research, and dissertation.

Application Domain Advisory Committee

The Program Director, the faculty lead associated with the student's chosen concentration, and a selected expert from the application domain related to the student's interest form the Application Domain Advisory Committee specifically designed for each student. This committee assists with the selection of appropriate courses and oversees the academic aspects of the student's program. It is constituted during the student's first semester. The committee members are consulted in the development of the student's plan of study and sign off on the plan. The Program Director and faculty lead choose the application domain expert, with input from the student.

If the student's research interests change, the Program Director may make changes to the Application Domain Advisory Committee to represent those interests while emphasizing curriculum coherence. Such changes may include replacing an Application Domain Advisory Committee member or enlarging the committee through appointing new members. Changes may be necessary at other times in response to changes in faculty roles and/or availability.

Second-year Research Project Advisor

A Second-year Research Project Advisor is selected from the Mathematical Modeling faculty based on the student's research interests, faculty research interests, and discussions with the Program Director. The Second-year Research Project Advisor should be selected and the Program Director informed of this choice no later than the beginning of the semester in which the student will complete this project, typically Spring of Year 2. Although the Second-year Research Project Advisor and the Dissertation Advisor often are the same person, it is not required.

Dissertation Advisor

A Dissertation Advisor is selected from the Mathematical Modeling faculty based on the student's research interests, faculty research interests, and discussions with the program director. The Dissertation Advisor should be selected no later than the beginning of the third year of study and preferably much sooner. It is possible for a student to choose two Dissertation Co-Advisors.

Dissertation Committee

After a student has chosen a Dissertation Advisor, the student, in consultation with the advisor, forms a Dissertation Committee consisting of four members, including the Dissertation Advisor. The committee includes, in addition to the Dissertation Advisor, one other member of the Mathematical Modeling faculty and a member external to the program appointed by the Dean of Graduate Education. The member external to the program must be a tenured member of the RIT faculty who is not a current member of the Mathematical Modeling faculty and must be approved by the Dean of Graduate

Education through petition by the Program Director. The fourth committee member must not be a member of the RIT faculty and may be affiliated with industry or with another academic institution; the Program Director must approve this committee member.

The main duties of the Dissertation Committee are assisting students in planning and conducting their dissertation research and providing guidance during the writing of the dissertation. In addition, the Dissertation Committee administers both the candidacy exam and the final dissertation defense. It is strongly recommended that students meet at least once per year with all committee members, including a meeting approximately six months in advance of the intended date of the dissertation defense. Regular meetings with the Dissertation Committee ensure that all members are aware of the student's progress and have the opportunity to communicate suggestions and concerns well in advance of the defense.

Additional Requirements

Seminar Attendance

All first- and second-year students are required to attend weekly seminars. First-year students typically attend these seminars as part of MATH-606 and MATH-607 (Graduate Seminar I and II).

Work-in-progress Presentations

After passing the Qualifying Examination and Second-year Research Project, each student is required to give at least one work-in-progress presentation each academic year. The presentations allow faculty and students to give feedback regarding both research directions and oral communication skills. All students in the program are required to attend the work-in-progress presentations.

Academic Integrity

All students are expected to adhere to high standards of personal and professional integrity. In particular, students must avoid breaches of academic integrity including cheating, duplicate submission, and plagiarism. More information about these topics along with the Student Academic Integrity Policy can be found at https://www.rit.edu/academicaffairs/policiesmanual/d080.

Code of Conduct

All students are expected to adhere to RIT's Code of Conduct, which includes avoiding behavior inconsistent with the university's mission. Examples of inappropriate behaviors include harassment, discrimination, endangering behavior, theft, and dishonest behavior. More information is available at https://www.rit.edu/studentaffairs/studentconduct/code-conduct. Students also must comply with the Code of Conduct for Computer Use, which ensures that computing, network, and information resources are used to support RIT's mission. Details regarding appropriate use of these resources can be found at https://www.rit.edu/academicaffairs/policiesmanual/c082-code-conduct-computer-use.

Program Milestones

Qualifying Examination

All students must pass a qualifying examination to determine whether they have sufficient knowledge of modeling principles, mathematics, and computational methods to conduct doctoral research. Students must pass the examination in order to continue in the Ph.D. program.

The Qualifying Examination is based on the Numerical Analysis I and the Mathematical Modeling courses. It includes written and practical exams on numerical analysis as well as a take-home modeling project with a written report. There also is a brief in-person discussion associated with the modeling project. This qualifying examination normally is taken shortly after the final examination period in May of the first year. However, students also will be offered a penalty-free chance to take the numerical analysis component of the Qualifying Exam in January shortly after completing the Numerical Analysis I course. If a student passes the exam during this penalty-free chance, no further examination of this area will be needed; if not, the student will not be penalized and will be allowed two later attempts to complete this portion of the exam.

After all portions of the Qualifying Examination have been administered, a committee designated by the Program Director will assess the student's performance and then inform the student of the result, which may be "Pass" or "Fail" for each component. Per RIT policy, students are allowed two tries to pass the Qualifying Examination. Note that the penalty-free first attempt for the Numerical Analysis component will not count toward these two tries. Students who do not pass the Qualifying Examination or any portions thereof should petition the Program Director to repeat any portions not passed by the beginning of the following semester (excluding summer). Students who have not passed all components of the Qualifying Examination after the second attempt are not permitted to continue in the program.

Second-year Research Project

Students are required to conduct a short research project based on the student's concentration foundation courses and additional material deemed appropriate. In most cases, students complete this project during Spring of their second year, after having completed the Concentration Foundation coursework, and should register for three research credits that semester (Spring of Year 2) in support of the project. The project should be completed, including a written research document and an oral presentation, by the end of the Final Examination period of the semester in which the work is conducted. The purpose of the project is for the student to demonstrate the ability to conduct independent research before beginning the dissertation.

Project Requirements

Students should identify a Second-year Research Project Advisor from the Mathematical Modeling faculty to supervise the project by the beginning of the semester in the work is performed. The Program Director should be notified of the choice of Second-year Research Project Advisor by email with the Second-year Research Project Advisor included in the email. Although it is advantageous for the Second-year Research Project Advisor to be the student's Dissertation Research Advisor as well, it is not necessary.

The project will be evaluated by a Second-year Project Evaluation Committee consisting of the Second-year Research Project Advisor and two other members designated by the Program Director, with input from the student and the advisor. The second committee member must be a member of the Mathematical Modeling faculty, often the faculty lead associated with the student's chosen concentration. The third committee member should be chosen to provide an additional perspective and is not required to be a member of the Mathematical Modeling faculty.

The student must submit a copy of the written research document to each member of the Second-year Project Evaluation Committee and to the Program Director in a single email at least two weeks before the oral presentation date. The presentation, which will be closed to the public, should be approximately 15-20 minutes long followed by approximately 15-30 minutes of discussion and questions from the Dissertation Committee. Along with the Second-year Project Evaluation Committee, the Program Director also attends the session, which otherwise is closed. The Second-year Research Project Advisor chairs the examination.

At the end of the session, the three committee members assess the student's written research document and oral presentation and then inform the student of the result, which may be "Pass" or "Fail," as described below. The Second-year Research Project Advisor also notifies the Program Director of the results.

Outcomes

The Second-year Research Project evaluation can have two possible outcomes: pass and fail. If the student's written research document and oral presentation are deemed satisfactory in both content and presentation, the student passes and is deemed to have satisfied the second-year research project requirement. If the Second-year Project Evaluation Committee members is not convinced by the written research document, the oral presentation, and subsequent questioning that the student has made sufficient research progress and communicated the work adequately, the committee members defer a their decision and identify what specific actions must be taken in furtherance of achieving an outcome of "Pass." Examples include pursuing the current research direction further, following an additional specified research direction, rewriting the research document to demonstrate proficiency in written communication, and improving the oral presentation.

A student who does not pass immediately must complete all specified actions and repeat the evaluation a second time in its entirety within two months according to the same guidelines. Any student in this situation is highly encouraged to communicate closely with the Second-year Research Project Committee members and the Program Director over this time period to ensure that adequate progress is made. A student who has not achieved an outcome of "Pass" by the second attempt receives an outcome of "Fail" and may not continue in the program.

Credit for Previous Graduate-level Research Experience

Students who enter the program already having completed comparable or more significant work in a graduate program, such as a graduate thesis, in some cases may be granted credit for the Second-year Research Project at the discretion of the Program Director. In such cases, students still may be required to submit their written research document and/or to give an oral presentation.

Candidacy Examination

When a student has developed an in-depth understanding of the dissertation research topic, the Dissertation Committee administers an examination to determine whether the student will be admitted to candidacy for the doctoral degree. The purpose of the examination is to ensure that the student has the necessary background knowledge, command of the problem, and intellectual maturity to carry out the specific doctoral-level research project. Requirements for the candidacy exam include both a written Dissertation Proposal and the presentation of an Oral Defense of the Proposal. The Candidacy Examination must take place at least one year before the defense of the dissertation. Students are strongly encouraged to pass the Candidacy Examination by the end of the third year and are expected to pass it by the end of the fourth year.

Dissertation Proposal

The Dissertation Proposal sets out the goals the student aims to accomplish in the dissertation. The topic should be selected by the student in consultation with the Dissertation Advisor. The proposal must outline the topic of the research to be undertaken, including the motivating questions, objectives, and/or hypotheses to be studied. It also should include a review of the literature, specific methods to be used to address the topic, and any relevant preliminary research results. In addition, the proposal should outline the research plan and directions for completing the dissertation along with a proposed timeline.

Oral Defense of the Proposal: Requirements and Guidelines

After writing the Dissertation Proposal, students must defend the proposal through an oral presentation followed by questions and answers from the Dissertation Committee. In conjunction with the Dissertation Committee, the student selects a date and time for the exam and notifies the Program Director and Program Assistant of the date and time. The student must submit a copy of the Dissertation Proposal to each member of the Dissertation Committee and to the Program Director in a single email at least two weeks before the Oral Defense date. The defense itself consists of a presentation between 45 and 60 minutes long followed by discussion and questions from the Dissertation Committee. The entire session is closed, and the Dissertation Advisor chairs the examination; the Program Director also may attend. At the conclusion of the exam, the committee members assess the student's written proposal and oral defense and then inform the student of the result.

The Candidacy Examination has three possible outcomes: pass, conditional pass, and fail. If the student's written proposal and oral defense are deemed satisfactory in both content and presentation, the student passes the examination and advances to candidacy. If the Dissertation Committee members have reservations about whether the student can or should complete their dissertation work according to the proposed plan, the examination outcome is a "Conditional Pass." In this case, the Committee identifies what specific remedial actions must be taken to change the outcome to "Pass." Examples include providing a better definition of the proposed topic and research plan, developing relevant preliminary results, and improving oral or written communication skills. It is not strictly necessary for the oral defense to be repeated in the case of a conditional pass, but the committee may choose to require it. A student earning a conditional pass must complete all specified actions within three months. The student's Dissertation Advisor verifies that all requirements have been met and reports the change of outcome to "Pass" to the Program Director. If the requirements have not been met within

three months, the outcome reverts to “Fail.”

If the proposal and defense are considered deficient, or if the student is initially awarded a conditional pass but fails to complete the requirements specified by the committee, the student fails the examination but is permitted to retake it a second time, with the same possible outcomes. In this case, the committee should detail the areas in which the original proposal and defense must be improved, and a minimum of three months must pass before the student can attempt the Candidacy Examination for the second time. A student who fails the examination a second time may not continue in the program.

The Dissertation and Defense

The course of study culminates in the dissertation. Each student must present original ideas and solutions to a specific mathematical modeling problem.

Scheduling the Defense

The final dissertation examination may be scheduled after the dissertation has been written and distributed to the Dissertation Committee and the committee has consented to administer the final examination. Copies of the dissertation must be distributed to all members of the dissertation committee and the Program Director by the same email at least four weeks prior to the final examination. A separate email should be sent at least four weeks prior to the final examination to the Program Director and Program Assistant providing the dissertation title and abstract; an appropriate figure if desired; and the date, time, and location of the defense. The Program Assistant can help in scheduling a room for the defense; the room should be reserved for three hours to prevent time pressures. The Program Assistant circulates an email announcement of the scheduled defense. The student is responsible for posting paper announcements in appropriate locations.

Prior to scheduling the defense, the student should contact the Program Director to verify that all other program requirements have been satisfied.

Exam Process

The final examination includes a public oral presentation of the dissertation research. The presentation should be approximately 45-50 minutes long and should be in the form of a research seminar. Slides should be prepared with appropriate visual aids. The presentation should address the specific problem being studied and why it is important in the application field; the objectives of the research; the methods used; the main results and accomplishments of the research; conclusions placing the achievements in context (e.g., “the first…,” “the fastest...,” etc.); and limitations and future work.

Immediately after the presentation, questions are fielded from the attending audience for approximately 10 minutes. At this point the defense is closed to all but the Dissertation Committee, and a private questioning of the candidate by the committee members ensues. The Program Director also may attend. The committee members may ask questions about the dissertation and about any relevant topical areas included in the research area or coursework of the program. The examination normally lasts about one hour. After the questioning, the student is excused and the dissertation committee deliberates. Once a decision has been reached, the student is invited back into the room and the Dissertation Advisor notifies the candidate of the result of the examination.

Exam Outcomes

The final examination has three possible outcomes: “Acceptable,” “Acceptable with minor amendments,” and “Not acceptable.” If the student’s written dissertation and oral defense are deemed satisfactory in both content and presentation as presented, the outcome of “Acceptable” is given. If the Dissertation Committee members agree that the dissertation work is acceptable overall but require changes to the written dissertation, the examination outcome is “Acceptable with minor amendments.” In this case, the committee members identify what specific changes must be made, and all changes must be made to the satisfaction of the committee within three months. The student’s Dissertation Advisor verifies that all requirements have been met and notifies the Dissertation Committee and the Program Director when that has occurred; after this time, the signature pages of the dissertation may be signed. If the requirements have not been met within three months, the outcome reverts to “Not acceptable.” If the committee members do not find the dissertation work acceptable, the outcome in that case also is “Not acceptable.”

Preparing the Dissertation for Publication

RIT recently announced that it no longer will require a printed bound dissertation copy for the RIT library as a graduation requirement. In light of this change, we are considering the advisability of requiring a bound copy for the Mathematical Modeling program office; in addition, we do not yet know whether RIT will continue to provide binding services for program or personal copies of the dissertation. More details will be made available by the time students are preparing to defend their dissertations.

Once the dissertation has been completed and accepted by the committee, the student should obtain signatures for the signature page or another alternative deemed acceptable by the Program Director. No signatures should be provided to the student until the Dissertation Advisor communicates to the Dissertation Committee and Program Director that all required changes have been made and the dissertation is now accepted.

The dissertation must be submitted in PDF form to ProQuest/UMI at http://www.etdadmin.com/rit following the submission guidelines. An additional fee may be assessed if the Open Access Publishing option is selected. It is imperative that the PDF does not include signatures. Additional detailed information regarding ProQuest/UMI submission can be found at http://infoguides.rit.edu/thesis-services.

In order to be certified for graduation, the student must submit to the Program Director by email (i) a signature page with original signatures or the equivalent to indicate the dissertation has been accepted and (ii) the confirmation received from ProQuest/UMI after electronic submission.

Copyright Law

The graduate student dissertation, when completed, is copyright-protected material. Copyright law establishes certain rights and ownership to the creator of original art, text, figures, etc. Students should understand the meaning of “fair use” and “copyright infringement” especially concerning the use of figures from other published material. Students should read and understand the information on using copyrighted works available at http://www.rit.edu/twc/academicintegrity/using-copyrighted-works .

Graduation Requirements

Commencement Participation Policies

Students who are expected to complete all degree requirements, including the dissertation defense, by the end of summer term may participate in the spring term graduation ceremonies. Those not having completed the dissertation defense with at least a conditional pass on or before April 1 and not having completed all other degree requirements as of the end of the spring term must have their likely spring- or summer-term completion documented by April 1 in letters of request to the COS Dean from their Dissertation Advisor and SMS Head. The letters should document approval of a specific planned defense date by the Dissertation Advisor, Dissertation Committee, and Program Director. The Dean makes all final decisions regarding participation in commencement ceremonies. Students may only participate in graduation and be listed in the commencement booklet one time.

Students must apply to participate in Commencement using the Application for Graduation Form available at http://www.rit.edu/academicaffairs/registrar/forms.

Degree Certification

Certification of a graduate degree requires verification that the student has completed all course and research credits required for the degree based on an approved Plan of Study as well as the Interdisciplinary Internship, Qualifying Examination, Second-year Research Project, and Candidacy Exam. The Dissertation Defense also must have been passed and the final dissertation submitted to ProQuest/UMI. In addition, the student must satisfy the residency requirement and time limitations and must achieve a minimum program cumulative grade point average of 3.00 (a “B” average). Full payment or satisfactory adjustment of all financial obligations is required. All materials must be returned to the Wallace Library. Certification for the degree occurs at the end of the term in which all requirements are satisfied.

Residency Requirement

As required by RIT policy, all students in the program must register for a minimum of 9 academic credits in each of two consecutive semesters (excluding summer) to establish residency in order to receive the doctoral degree; see https://www.rit.edu/academicaffairs/policiesmanual/d120.

Time Limitations

RIT policy requires that doctoral programs be completed within seven years of the date of the student passing the qualifying exam. The purpose of the rule is to ensure that graduate students have current knowledge in their fields of study when certified for graduation. All candidates must maintain continuous enrollment during the research phase of the program. This enrollment is not limited by the maximum number of research credits that apply to the degree. Normally, full-time students complete the course of study for the Ph.D. in an average of four to five years, depending on the degree level upon entering the program and many other factors. If extenuating circumstances prevent a student from completing the program requirements within seven years from the date of passing the qualifying exam, an appeal must be made to the Dean of Graduate Studies. Petition for such an extension is initiated through discussion with the student’s Dissertation Advisor and by written request to the Program Director, who then petitions the Dean of Graduate Education. See

https://www.rit.edu/academicaffairs/policiesmanual/d120 for more information about the Seven-year Graduation Rule.

Other Information

Financial Support

Full-time students normally are supported by a stipend and full tuition remission through First-year, Research, or Teaching Assistantships during Fall and Spring semesters. Summer funding may be provided for students supported through Research Assistantships and may be available occasionally to students supported through Teaching Assistantships. Assistantships are subject to employment law and RIT policies governing the types of activities that can be undertaken and the number of hours to be worked per week.

It is expected that each full-time student admitted with an offer of financial support will be provided an assistantship through at least one of these mechanisms during the academic year for the duration of the program as long as satisfactory progress is being made toward the degree. The Program Director and the Dissertation Advisor (once identified) determine whether progress is satisfactory. Students notified of unsatisfactory progress are allowed at least one semester to demonstrate improvement; if sufficient progress has not been made, assistance may be withdrawn at that time.

Part-time students may be awarded partial scholarships to offset tuition costs.

First-year Assistantships

Most full-time first-year students are supported through First-year Assistantships. Students supported in this way generally are required to assist in calculus workshops and to grade assignments for calculus classes. Students will not be asked to teach classes or to run workshop or recitation sections independently when supported by a first-year assistantship.

Research Assistantships

Students working with faculty members who have external or internal funding available to provide support may be offered Research Assistantships. Research Assistantships typically would not be offered to first-year students except for students with backgrounds sufficient to allow them to make contributions to research immediately; such students often have master's degrees in related fields and/or significant prior research experience. Although it is expected that most students supported by Research Assistantships will choose the faculty member providing the assistantship as their Dissertation Advisor, this is not strictly necessary and can be negotiated by those involved.

All members of the RIT research community are expected to adhere to the highest ethical and professional standards as they pursue research and scholarly activities. Thus, all RIT community members engaged in research and scholarly endeavors must comply with the legal, regulatory, contractual, and ethical requirements established by the University, regulatory agencies, funding sources, and applicable professional organizations. In particular, students who are working as Research Assistants supported by funding from the National Science Foundation (NSF) must complete the Responsible Conduct of Research training provided by RIT to satisfy NSF's Responsible and Ethical Conduct of Research requirement. All students are strongly encouraged to take this training when they

are first supported as a Research Assistant or by the end of their third semester, whichever comes first.

Teaching Assistantships

In addition to Research Assistantships, students may be supported through Teaching Assistantships. Teaching Assistants are involved in classroom activities beyond the level expected for those students supported by First-year Assistantships. For example, Teaching Assistants may run workshop or recitation sections for calculus classes or for other courses. Students with Master's degrees are eligible to teach courses as well if considered appropriate. Teaching Assistants are likely to be engaged in a broad spectrum of activities, such as class preparation, development of instructional materials, classroom management, grading, answering student emails, and holding office hours.

Students supported by Teaching Assistantships are required to participate in teaching training and evaluation activities deemed appropriate prior to and during the time they are engaged in relevant activities.

Facilities

The Wallace Center

The Wallace Memorial Library (http://library.rit.edu) is a high-technology, multimedia resource center containing more than 700,000 items. Services include interlibrary loans, computerized literature, searching of databases, and class instruction. Each RIT college has a Reference Librarian to serve as liaison. The College of Science liaison is Dr. Adwoa Boateng (http://infoguides.rit.edu/prf.php?account_id=43305); she can be contacted for consultation and assistance related to research needs.

Computing Services

The RIT computing environment includes support provided by Information and Technology Services. Every enrolled RIT student receives a username and password that may be used to access computer laboratories, library services, and assistance to connect student computers to RIT's network for Internet access and communicate with others electronically. Students can contact the Information & Technology Services at (585) 475-HELP (4357) or visit https://start.rit.edu for assistance and service support.

Students also have access to programming and simulation languages, graphics software, and design tools on a variety of platforms.

Academic Support Services

RIT offers a wide variety of academic support services for students. An excellent list of services offered is available at https://www.rit.edu/studentaffairs/parentsandfamilies/academic-support-services.

Disability Services

RIT is committed to providing reasonable accommodations to students with disabilities. If you need

accommodations such as special seating or note taking services due to a disability, please go to the Disability Services Office. It is located in the Student Alumni Union, room 1150. If you receive accommodation approval, you must make the instructors aware of this fact prior to the date that accommodations will be necessary.

Mental Health

All aspects of students' health are important, including mental health. Being a graduate student can be stressful and all students are encouraged to take care of their mental and emotional health needs. RIT has resources available to support students; see https://www.rit.edu/studentaffairs/tigerscare/.

Program Communication

Email is the primary mode of communication used to contact students. Every enrolled student is strongly advised to check for RIT email messages regularly and to forward RIT email if another service is used for primary email service.

Students will have regular interactions with other students and faculty through formal opportunities, such as research and work-in-progress seminars, and through informal social events. All students in the program will meet as a group at least once annually with the Program Director. Individual progress also will be assessed at least annually by the Program Director and, once chosen, the Dissertation Advisor.