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Chapter 1

Introduction

This guide to graduate study in the Department of Computational and Applied Mathematics contains information about exams, monetary support, required and recommended courses, and regulations and rules for the various degree programs. It is intended to supplement the General Announcements by providing a more detailed description of the CAAM graduate program.

This handbook is the result of an ongoing attempt by the faculty to codify and make readily available to students the rules, requirements, and general approach to the graduate education of our department. Please do not hesitate to notify the faculty about areas that need clarification or strengthening.

—The Graduate Committee
Department of Computational and Applied Mathematics, 2004-2005

William W. Symes, Chair

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Staff Assignments:

Fran Moshiri is responsible for budgetary matters and accounting, as well as the overall administration of the Department. Her office is in 2109 Duncan Hall.

Daria Lawrence is, among other things, our Graduate Secretary. She handles graduate matters such as registration, payroll, announcing and administering exams, and providing information on policy, procedure, and required paperwork for PhD candidacy and graduation. Her office is in 1079 Duncan Hall.

Ivy Gonzalez is our Webmaster. In addition to departmental document production and maintenance, she provides general clerical support to department faculty in academic matters. Her office is in 1089 Duncan Hall.

Margaret is our front-office staff member who provides the department with basic clerical support. Margaret handles expense reports and reimbursements. Margaret is also the colloquium secretary. Margaret also handles other academic matters that are not handled by Daria Lawrence or Ivy Gonzalez. Her office is in 1078 Duncan Hall.

Eric Aune is the information systems administrator assigned to CAAM and STAT. His domain includes the CAAM research network (mostly Sun SparcStations and Linux workstations) and the office computing equipment. Any hardware and/or software problems with the departmental computer system should be reported to Eric forthwith.
CAAM Committees:

Computing Committee:

- Matthias Heinkenschloss, Chair
- Tim Warburton

Graduate Committee:

- Liliana Borcea, Chair
- Matthias Heinkenschloss
- Dan Sorensen

Undergraduate Committee:

- Steve Cox, Chair
- Mark Embree

Course Committees:

1. **Analysis**:

   - Liliana Borcea
   - Steven Cox
   - Matthias Heinkenschloss
   - Williams Symes

2. **Numerical Analysis**:

   - Mark Embree
   - Mathias Heinkenschloss
   - Dan Sorensen
   - Richard Tapia
   - Yin Zhang

3. **Computational Science**:

   - Steve Cox
   - Mark Embree
   - Michael Fagan
   - Dan Sorensen
   - William Symes
Other Departmental Services:

Colloquium: Steve Cox, Chair

Library Liaison: Mark Embree

Graduate Management:

Grad Representatives:

• Mili Shah
• Kai Sun

SIAM Chapter:

• Eric Dussard
• Fernando Guevara
• John Sabino

Social Committee:

• Leila Issa

Seminar Speaker Committee:

• Fernando Gonzalez del Cueto
• Fernando Acosta
Chapter 2

Getting Started

**Arrival:** The first thing to do upon arriving on campus is to see Daria Lawrence, the Department Coordinator. Her office is in 1079 Duncan Hall. She will explain the process of obtaining an ID card and a parking sticker, establish a paycheck schedule, and otherwise smooth the student’s adjustment to campus life.

**The Monitor System:** The graduate committee assigns a faculty member to each individual to act as his or her *monitor*. Each student will meet with their monitor early in each semester to discuss curriculum choices, examinations, and so forth. A faculty monitor will be present throughout a student’s graduate career. After a thesis advisor has been acquired, the advisor will take over the monitor’s role.

Graduate students normally register during the first week of classes; a registration form can be obtained from Daria Lawrence. In order to file the registration form, the faculty monitor’s signature is needed. The monitor will also help ensure the student’s choices and plans are in tune with the various requirements for his or her degree program.

Note that courses can be added after the first week — a course can be added for free until the end of the 2\(^{nd}\) week. From then until the fourth week of classes, a nominal fee will be incurred for course additions. Classes can be dropped until the tenth week of the semester; consult the academic calendar for exact dates. Therefore, the schedule established in the first week is not chiseled in stone and can be adjusted for quite a while. The semester is only 15 weeks long, so it is encouraged not to take too long in the selection process. The student’s monitor and the course instructor should approve any drop or add.
**The Entrance Interviews:** The first semester is special – students and faculty members are getting acquainted with each other. To speed this process along, interviews are scheduled for each student with two committees of professors. This usually takes place the Thursday of orientation week (the week before classes begin). These two committees will discuss the student’s background in mathematical and numerical analysis, and in computing, respectively. Based on what they learn from the interviews, the committees will recommend initial coursework; this recommendation will be passed on to the student’s monitor. Particularly well-prepared entering students may be advised to try one or both qualifying examinations (see Chapter 5 for more on this). Most importantly, some of the faculty will have the opportunity to chat with the student and learn a bit more than was possible during the admission process about what the student has learned and their ideas about their course of study at Rice.

**Coursework:** In the fall of 1995, CAAM instituted a system of required courses to which students must conform. That curriculum has been revised for the students entering in the Fall of 2002 and beyond. The required course system is described in Chapter 4. Course choices will depend on individual interests. The required course list for students who entered in 1995 or later includes courses from all areas of concentration in CAAM. The Department also encourages the student to take graduate-level courses in other departments such as the Mathematics and Computer Science Departments. Outside courses (at the graduate level) will count toward the semester hour requirement of the degree. The only restriction applies to non-thesis (“professional”) Masters in Computational and Applied Mathematics candidates, who may count only two courses outside the department toward the degree. See the General Announcements for more details.

Some entering students have acquired enough background that they have no need for CAAM’s introductory courses. For most students, however, the introductory courses are worthwhile. An even deeper background coursework is advisable for some students.

**Computers:** Access to computers is essential for graduate study in CAAM. Each graduate student has access to two computer systems during their stay at Rice.

Every graduate student whose courses require computational work is entitled to an educational computing account through Owlnet, a network of Unix workstations with labs in various campus locations. Owlnet is specifically intended for coursework use. To sign up, go to the help desk in the Mudd Building, and ask for directions on acquiring an Owlnet account. A student can also apply online at http://apply.rice.edu. The help desk will inform the student where the Owlnet labs are located. Note that the Owlnet accounts are per course; if a student cannot point to a course in their current schedule that requires computing assignments, he/she may have trouble securing an Owlnet account. Since most CAAM courses require computing (eg. 420, 452, 453, 454,...) this restriction should not be much of an impediment.

On arrival at Rice, every graduate student is also assigned an account on the departmental computing system. The CAAM system consists of several desktop workstations and file servers in offices, including one public lab (3132 Duncan Hall); administrative computers (PC’s); and peripherals (printers), linked by Ethernet and to the outside world through the campus fiber optic backbone. Wireless connections are also
readily available. Software includes Matlab, Maple, Web browsers, \TeX\ in various forms, alternative compilers (eg. GNU), and much more.

Research groups within the department maintain several high performance systems, which are available for use by members of these groups. At the moment these include several PC or DEC Alpha clusters (“Beowulf” systems), an SGI Origin 2000 shared memory multiprocessor, and a Sun Enterprise shared memory multiprocessor. Further, a large number of additional on and off-campus high performance systems are available through our associations with various centers, institutes, and national laboratories.

**English proficiency and technical writing:** Ability to write and speak English competently is *essential* for successful academic work at Rice, and in fact has become essential for scientific careers worldwide. The Department reinforces its commitment to fostering speaking and writing skills in the following two ways:

1. It is required that all non-native English speakers whose TOEFL scores are near or below the official admission criterion (currently 600) should 1) retake the TOEFL and 2) enroll in an ESL class for at least one semester. If the student is required to take these steps, they *must* do so to receive their stipend.

2. It is strongly recommend that *all* graduate students participate in the thesis writing groups organized by the Cain Project. The Cain Project, directed by Professor Driskill in the English department, aims to raise the level of writing competency throughout Rice, but particularly in science and engineering. The thesis writing groups have been extremely helpful for those students who have participated over the last several years. As one might guess, a student should be involved in writing a project-master’s or PhD thesis or thesis proposal to participate.

**And So On…** Other helpful information on life as a graduate student can be found in the Graduate Student Association (GSA) yellow pages. The URL for GSA is:

http://www.ruf.rice.edu/~gsa/yellow-pages/

The student will also want to check out the library (Fondren Hall) and Valhalla, the graduate student pub. The Rice University Student Handbook also contains a wealth of useful information.
Chapter 3

Financial Support

Rice is somewhat unusual in that relatively few graduate students support themselves by teaching. Almost all CAAM graduate students receive stipends and tuition – either from the university or from an external research grant awarded to a CAAM faculty member. As a result, the chief business of graduate school, for most of our students, is preparing for and learning to carry out research in computational and applied mathematics.

A limited number of teaching assistantships are available to those who wish to acquire teaching experience. Since some evidence of teaching competence is a prerequisite for entry-level academic positions, CAAM graduate students who wish to eventually become professors should take advantage of this opportunity to enhance their vitae in this important way.

The TA program has grown considerably in the last few years. Under the NSF VIGRE Program, each year several graduate students serve as classroom instructors for small sections of introductory courses – such as CAAM 210 (Introduction to Engineering Computation) and CAAM 335 (Matrix Analysis). Please see the Graduate Committee chair for current information on teaching opportunities and requirements.

The Office of Graduate Studies supports most incoming PhD students during the first year of studies and a few individuals in later years. This support includes a stipend and tuition. At the beginning of each year additional payments for fees, health insurance, and parking to name a few are required; it usually amounts to around $475.00.

In return for university support, the department asks the student to perform some service – usually in the form of grading homework and exams for courses. At the beginning of each semester, the graduate committee assigns most graduate students as graders to various courses. Grading is an important responsibility and is NOT to be taken lightly. Failure to perform grading duties adequately may jeopardize future support. If
for some reason a student feels unable to grade in the assigned course, they should inform the graduate chair so that the chair can attempt to reassign the student.

Stipends for first year students cover their entire first year, from August 16 to August 15 of the following year. In virtually all cases, stipends funded by research grants also cover the full year and not just the academic year. Graduate study in CAAM is usually a full-time year-round activity! Summers are extremely valuable work time, because there is the opportunity to perform research without the distractions of coursework, grading, etc.

If a student wishes to absent themselves from Rice during the summer, either to take on an internship or for another activity, please inform the Department Coordinator as early as possible so that good use can be made of the stipend funds that are not needed.

Some university funds may be available to support students in subsequent years of graduate study. However, in general, students in the CAAM department obtain their support from research grants after the first year. The opportunity to do research is an integral part of graduate training. Each student is responsible for identifying this opportunity, deciding which of the faculty to work with, and approaching him/her about support (and a project!). While the department is not in a position to guarantee a research assistantship with one of the faculty, CAAM has been very successful in placing students with professors throughout its 30+ year history. The professors always have projects underway; therefore, more often than not, they are looking for research assistants. Since our faculty has been vastly more successful than the average math department in raising research money, very few students have had any trouble finding an intellectual berth with a stipend. The coursework over the first two or three years will help familiarize the students with the professors and vice versa. Enthusiastic participation in a student’s early classes is by far the best way to find a faculty member (or to have him/her find you) who will direct the student’s initiation as a scientist to the mutual benefit of everyone.

As a matter of University policy, Rice does not offer financial support to non-thesis (“professional” or MCAM) students. Accordingly, transfer from the PhD program to the non-thesis master’s program implies repayment of any financial aid received from Rice. This restriction does not apply in case of transfer to the thesis master’s program (MA degree). In years past, a small number of these students have chosen to make such a transfer as a way of leaving the PhD program without a PhD but with a master’s degree. Students who choose to transfer from the PhD program to the MA (master’s with thesis) program will not be subject to repayment of previous financial aid.

If financial aid, beyond what the department has arranged, is needed, the student may contact the Financial Aid office for information about loan programs for graduate students.
Chapter 4

The CAAM Graduate Curriculum

Computational and Applied Mathematics is a rapidly evolving and essentially interdisciplinary field. The most fascinating work in CAAM often involves surprising combinations of ideas from various parts of mathematics, statistics, computer science, physical sciences, engineering, as well as many other disciplines.

CAAM faculty members established a core curriculum designed to ensure breadth of exposure to all areas of computational and applied mathematics, as represented by the Rice faculty and depth of preparation in a disciplinary area. Both the core and the disciplinary curricula evolve as faculty and student interests change. In the spring and summer of 2002, CAAM faculty undertook a major revision of the course structure, intended to streamline and rationalize the introductory and intermediate offerings and to permit the faculty to offer more advanced courses in their research specialties.

The current curriculum consists of (i) five required courses, of which every CAAM PhD student must complete; (ii) eight distribution courses of which CAAM PhD students must complete four; and (iii) elective courses. Both the five required courses and four distribution courses must be completed before a student advances to PhD candidacy status and should not be taken as Pass/Fail.

These requirements apply to students admitted to the PhD program in Fall 2002 or later. Students admitted earlier than Fall 2002 will complete the requirements described in the handbook for their entrance year. They will use currently offered courses as suggested by their monitor/advisor and approved by the Graduate Committee chair.

In some cases, these requirements may not be appropriate, because of prior, equivalent course work. The graduate committee will consider such exceptions as they arise. Our intent is not to construct rigid constraints, but rather to ensure that every CAAM PhD has a broad grounding in applied mathematics. The course of study described here should accomplish this goal for almost all CAAM students, insofar as it can be accomplished at Rice.
Introductory Courses

Purpose: To expose each CAAM student to the range of computational and applied mathematics as represented by the faculty and to serve as the foundation for all further work.

Timing: Students should attempt to complete the required courses within the first year of graduate study. However, in any case, these courses must be completed prior to advancement to PhD candidacy.

Exceptions: In some cases, an alternative selection of courses might suit a student’s needs better than the required list. An example is a result of previous study. A student may develop an alternative program of coursework with the help of a faculty member and present it to the Graduate Committee for its approval. The alternative course of study should respect the intent of the required list by achieving comparable breadth. An approved copy of the student’s curriculum should go in their graduate student file.

Introductory Courses:

CAAM  401 Analysis I
CAAM  402 Analysis II
CAAM  420 Computational Science I
CAAM  435 Dynamical Systems – Theory and Computation
CAAM  436 Partial Differential Equations of Mathematical Physics
CAAM  437 Methods of Mathematical Physics
CAAM  453 Numerical Analysis I
CAAM  454 Numerical Analysis II

Distribution Courses

Purpose: To provide further exposure to a wide range of topics and ideas and to guide the beginning of concentration on a specialty.

Timing: Four out of the eight distribution courses should be completed during the first three years. Whatever the case may be, this four-course requirement must be completed before advancement to PhD candidacy.

Exceptions: Same as for the required courses.

Distribution Courses:

CAAM  415 Mathematical Neuroscience
CAAM  436 Partial Differential Equations of Mathematical Physics
CAAM  452 Numerical Methods for Partial Differential Equations
CAAM  460 Optimization Theory
CAAM  540 Applied Functional Analysis
Intermediate Topics Courses

**Purpose:** Complete preparation for research in one of the CAAM disciplines.

**Timing:** Throughout graduate study, but concentrated in the first three years.

**Preparation and Exceptions:** Enrollment in these courses requires completion of one or more required or distribution courses, or the equivalent. A program for each student will be developed in consultation with advisor(s). Some courses in other departments require preparation beyond what is outlined here.

### Intermediate Courses

- **CAAM 464** Numerical Optimization
- **CAAM 520** Computational Science II
- **CAAM 551** Numerical Linear Algebra
- **CAAM 552** Partial Differential Equations
- **COMP 421** Operating Systems and Concurrent Programming
- **COMP 422** Parallel Programming
- **COMP 425** Computer Systems Architecture
- **ELEC 695** Advanced Digital Signal Processing
- **MATH 425** Real Analysis
- **STAT 486** Methods in Computational Finance
- **STAT 531/2** Advanced Mathematical Statistics I/II

**Topics Courses:** In addition, each research group offers topics courses (numbered 6XX), which vary in number and content according to faculty interest and student demand. These courses present advanced material in CAAM research areas and are often structured as seminars.

### Colloquia and Seminars

In addition to the program of course work detailed above, department colloquia and seminars form an essential part of graduate education. All students are expected to attend the regular department colloquia. These talks, generally given by speakers from outside Rice, describe current research at the frontiers of applied and computational mathematics. Therefore, they give graduate students an overview of the breadth of the field’s discipline. Interested students are encouraged to meet individually with the visiting speakers.

CAAM students also attend the Graduate Research Seminar (CAAM 500). These talks, generally given by fellow students and CAAM faculty, are both less formal and more introductory than the department colloquia. These seminars also provide opportunities
for new students to identify potential faculty advisors. (Please note that the one credit hour for CAAM 500 does not count toward the minimum nine credit hours required of full time students.)
Chapter 5

The Masters Thesis and Qualifying Examination for Admission to PhD Candidacy

Advancing to PhD candidacy requires satisfactory performance on two Qualifying Examinations (Analysis and Linear Algebra & Numerical Analysis) and satisfactory completion and defense of a Master’s Thesis.

The Qualifying Exams: The Analysis and Linear Algebra exam is based on material taught in CAAM 401/402. The Numerical Analysis exam is based on material taught in CAAM 453/454. These two or three-hour exams will be administered twice per year – during finals week of the spring term and in the week before classes in the fall term. Students will normally take CAAM 401/402 and CAAM 453/454 in their first year. They then take the Qualifying Examinations during finals period of the spring semester of their first year. Only one retake is permitted. This typically takes place in the week before classes begin in the following fall semester. The retake is also a two or three-hour written exam.

Well-prepared students may be invited by their entrance interview committees to attempt one or both exams. Failure to pass either exam, when invited, will be without penalty; a fail result will simply be discarded. The student will then be required to take the corresponding course sequence (401/402 and/or 453/454) and take the exam again in the spring, as if for the first time.

These exams will have the same scope and nature as final exams in the respective courses. However, they will be administered only to CAAM graduate students and will have no bearing on the course grades. The exams are open to both CAAM graduate students who have entered with a declaration that the PhD is the degree sought and to others who wish to enter the PhD program.
The Committees: Each of the two basic graduate sequences (401/402 and 453/454) will be overseen by a committee of present, former, and possibly future instructors, who will author the respective exams. The current course instructors will participate in the design of the exams, but the end product will be the work of course committees. The course committees will be listed in the Grad Handbook each year. Students are welcome to consult anyone on the committee about the exams and their contents.

Students facing the Qualifying Exams are strongly encouraged to form study groups to present course material to each other, to tackle homework problems as well as unassigned problems and old exams, and in general, take an active role in making this fundamental material their own.

Masters Thesis: A student should complete and defend their Masters Thesis by the end of the spring semester of their second year. A committee headed by a thesis advisor will supervise the thesis. Ordinarily the student will take three hours of thesis credit in the spring semester of the second year to provide sufficient time to complete the thesis. Thesis topics and scope will be agreed upon between the student and their thesis advisor. It will usually be chosen to make the likelihood of completion in the suggested time frame as high as possible. By the end of the fall semester in the second year, the committee should be constituted and the topic chosen. These choices are to be reported to the Chair of the Graduate Committee and the Graduate Secretary. The thesis committee will assign to the defense one of three grades: (1) satisfactory, PhD (2) satisfactory, MA or (3) fail. These grades, like the pass/fail in the Qualifying Exams, represent the judgment of the faculty as to the suitability of the student to continue in the PhD program.

The faculty will meet at the end of the spring semester, if necessary at other times as well, to review and confirm results of both Qualifying Exams and MA Thesis Defenses. Those who have passed the Qualifying Exams and received “satisfactory, PhD” in the MA Thesis Defense will receive the MA degree at the immediate following commencements. They will then be invited to continue in the PhD program – complete the requirements for candidacy; namely the writing of the PhD thesis proposal and its defense. Those who receive a grade of “satisfactory, MA” will receive the MA degree at the immediate following commencement, but will not be invited to continue in the PhD program, regardless of success in the Qualifying Exams. A failure in the MA thesis defense will result in no degree being awarded and no invitation to continue being issued.
A student who has previously completed a Master's thesis in another department or at another university may petition the graduate committee to waive the Master's thesis requirement. A written request for a waiver, along with three copies of the thesis, should be submitted to the Graduate Committee after the student passes the written qualifying exams, but no later than the end of the first week in the second Fall semester. This petition should briefly explain the topic and contribution of the thesis; the student may be asked to give an oral presentation about this work. A waiver will be granted provided the Graduate Committee judges that the thesis meets the standard of the CAAM "Satisfactory, PhD" grade for MA theses; otherwise the student must write an MA thesis. Those who obtain waivers will still have the option to receive an MA degree later by submitting their PhD proposals as Master's theses.

**The PhD Thesis:** The PhD Thesis Proposal may be an extension of the MA Thesis or may be completely independent. Ordinarily the proposal will be a separate document and its defense a separate exam. In exceptional cases, the student’s committee may decide to consider the Masters Thesis (with grades of “satisfactory, PhD”) as also a successful PhD Thesis Proposal Defense, with paperwork to that effect. This option requires assent of the Graduate Committee and should be cleared with the Graduate Committee well before that defense. It also implies that the masters thesis committee has agreed to serve as the PhD thesis committee, as it will play that role in the defense as well.

**Exceptions:** Exceptions to these rules will be handled on an individual basis according to the grievance procedures outlined below. Amongst these exceptions is delay in the completion of the Masters Thesis. Such extensions should be requested in a letter to the graduate committee stating the reasons for the extension (beyond the second semester of the second year). The student’s MA thesis advisor will be asked for concurrence in this particular exception. For example, it may in some cases be reasonable to extend the date of the MA Thesis Defense if it has been agreed between student, MA thesis committee, and Graduate Committee that the MA Thesis will do double duty as a PhD Thesis Proposal. However, the student and thesis committee should take account of the risk that the added time and effort may not lead to PhD candidacy.

**Grievance:** All requests for exceptions or variances from the policies outlined above should be addressed to the Graduate Committee and delivered to the Chair of this committee. Grievance letters should state precisely what exception or variance is requested and detailed reasons given to support the request. Either the Graduate Committee or the full faculty will decide the issue, as appropriate.
Appendix

CAAM Policy on Student Computing*
*Updated August 2002

The CAAM department provides computing resources to students for the purposes of research and education. The acquisition, operation, and maintenance of the computing resources are supported by university and faculty research funds. This policy provides students with guidelines on proper usage of the computing resources. Any doubts about appropriate usage should be resolved by query to the System Administrator or the faculty Computer Committee.

1. All graduate students in the MA, MCAM, and PhD degree programs can have accounts on the CAAM system. New graduate students should fill out a form, available from the department coordinator and/or graduate secretary, to request the creation of new computer accounts.

A faculty sponsor can request accounts for undergraduate students or non-CAAM graduate students, who are involved in a faculty-sponsored research or educational project. To obtain such an account, a student must submit a request form with the signature of a faculty sponsor.

2. Students may use office desktop equipment to
   a. read and write email
   b. create and maintain a personal web page
• browse the Web for educational or research purposes
• log in to Owlnet for computational coursework
• perform teaching functions (grading, TA work, etc.)
• perform research on faculty-led projects (includes thesis research)

In all cases, research-related use has priority.

3. Students may use non-desktop departmental equipment (printers, scanners, computing and file servers...) to

• perform research on faculty-led projects (includes thesis research)
• perform teaching functions (grading, TA work, etc.)
• store small amounts of information unrelated to their research projects, including email and a personal web page.

4. As long as it does not interfere with research and education use, printing and copying of personal material is permitted – for a fee (currently $0.06/page). Students will keep track of personal printing and copying, and pay any such charges periodically (preferably monthly) in the department office.

5. Students may not use departmental equipment to

• play computer games, chat online, and things of similar nature unrelated to the educational and research missions of the university;
• store, print, or process significant amounts of information of a purely personal nature or unrelated to the educational and research missions of the university, without reimbursing the department as outlined in item 4.

6. Termination of computer accounts: A CAAM graduate student's account will be terminated one year after the student's enrollment as a CAAM student has ended. Former students who continue their collaboration with the faculty after graduation can retain their accounts upon the request of a faculty member. The account for an undergraduate student or a non-CAAM graduate student will be terminated six months after the student's involvement in a faculty-sponsored project has ended.

7. In addition to the specific policies outlined above, students are bound by the Rice computing policy, see:

8. The system administrator will respond to infractions of these policies in consultation with the Computer Committee. Response to serious infraction may include closing of the guilty party's account.