BROWN UNIVERSITY
Division of Applied Mathematics
Handbook for Graduate Students

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Introduction

Our graduate program provides training and research activities in a broad spectrum of applied mathematics. The principal areas of research activities represented in the Division of Applied Mathematics are ordinary, functional, and partial differential equations; probability, statistics and stochastic systems theory; neuroscience, pattern theory, and computational biology; numerical analysis and scientific computation. The effort in virtually all the research areas ranges from applied and algorithmic problems to the study of fundamental mathematical questions; many of our faculty are engaged in interdisciplinary research collaborations with colleagues here at Brown or elsewhere. This breadth is one of the great strengths of the program and is further reflected in the courses we offer. We also offer a variety of professional development opportunities, including teaching, internships in industry and national labs, and roundtable discussions on professional issues. The Division hosts a large number of postdoctoral fellows and faculty visitors who actively contribute to our research programs and to graduate education. We also host several research seminar series in the Division; in addition, the Institute for Computational and Experimental Research in Mathematics (ICERM) hosts semester-long programs that are attended by many of our graduate students and faculty.

This handbook is intended to give you an overview of the graduate program in the Division of Applied Mathematics at Brown University and to answer some of the commonly raised questions about policies and procedures. Jean Radican (Senior Graduate Program Coordinator), Kavita Ramanan (Director of Graduate Studies) and your academic advisor can help and advise you on any issues not covered in this document.

Overview of timelines and milestones

The following paragraph provides a brief overview of the timelines and milestones during your PhD studies: details are contained in the following subsections.

Graduate students spend typically 5 (or on occasion 6) years on their PhD studies. During the first two years, you take courses and serve, usually during your second year, as Teaching Assistants (TAs) to satisfy our teaching requirements. During this time, you will also identify the research area and a thesis advisor with whom you want to work on your PhD thesis. Before the start of your third year, you should have taken your preliminary examination (the “prelim”), which serves as your formal admission to doctoral candidacy. The prelim is an oral examination on topics based on four two-semester course sequences, so we advise you to plan ahead as you design your course program during your first two years. After passing the prelim, you may enroll in additional topics courses or other courses: your main effort, however, will be directed towards working on your PhD research topic with guidance from your thesis advisor.
A typical schedule therefore looks as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Courses per Semester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>4 courses per semester</td>
</tr>
<tr>
<td>Year 2</td>
<td>3 courses per semester; TA for one course per semester; identify thesis advisor; take prelim exam</td>
</tr>
<tr>
<td>Years 3-5</td>
<td>Thesis work ending with your PhD thesis defense</td>
</tr>
</tbody>
</table>

Every graduate student has a faculty advisor at all times during graduate study in the Division. Incoming graduate students are assigned a temporary Academic Advisor. After students pass the preliminary exam, they work with their thesis advisor.

**Advising and mentoring**

**Director of Graduate Studies**

Kavita Ramanan is the Director of Graduate Studies. The Director of Graduate Studies oversees all internal aspects of our graduate program (including TA assignments), advises graduate students, and signs all departmental forms that pertain to the graduate program.

**Senior Graduate Program Coordinator**

Jean Radican, our Senior Graduate Program Coordinator, performs most of the administrative work of our graduate program. You should check with her if you have any questions of an administrative or procedural nature.

**Academic Advisor**

In the spring prior to entering our graduate program, each graduate student is assigned an Academic Advisor who is a member of the Division’s faculty—you may request a specific faculty member as your academic advisor if you wish. The Academic Advisor helps you during your first two years with all academic matters such as choosing courses, preparing for the prelims, thinking about possible future thesis research areas, and identifying potential thesis advisors. The Academic Advisor needs to approve your course selections and any changes to your course program during the semester.

**Thesis Advisor**

The Thesis Advisor provides the main guidance during your PhD thesis research. The Thesis Advisor can be any faculty member from the Division, or even from another department at Brown University, though students should consult both with their Academic Advisor and the Director of Graduate Studies if they plan to work with a Thesis Advisor from another department.
You should select a Thesis Advisor by the end of the first semester during your second year. The Thesis Advisor will advise you on the course selection for the preliminary exam and will usually also serve as the Chair of the Prelim Exam Committee. We encourage you to consider possible research areas and Thesis Advisors early, but you should not feel pressured to commit yourself before you are sure. The Division's philosophy and funding structure is such that students with initial fellowship support are under no pressure to determine a Thesis Advisor until the end of the first semester of their second year. When choosing a Thesis Advisor, you should consider foremost whether the research subject is what you like the most, whether you have a good background in that area, and whether you want to work with the particular faculty member as your advisor. If you are interested in the research of several professors, you should feel free to talk to all relevant faculty members to get an idea of what they work on; it also often helps to take independent study courses with different professors, to work with faculty members over the summer on research projects, or to talk with other students to get a better sense of specific research areas or advisors.

Occasionally, a student may find it necessary to change the Thesis Advisor. There are no restrictions on doing so, but the student should discuss the matter with both the old and the new Thesis Advisor, and with the Director of Graduate Studies, before making such a change.

Additional resources

Academic buddies: During your first year, we will ask a more senior graduate student to serve as your academic buddy; your academic buddy will provide you with informal advice and guidance from a student’s perspective.

Help with graduate courses: Some of the graduate courses can be challenging. If there is interest, the department can organize informal sessions in which senior graduate students help with the course material. If you are interested, please contact the Director of Graduate Studies.

Rose Whelan Society: The Rose Whelan Society provides informal support for women graduate students and postdocs in the applied mathematics and mathematics departments at Brown. To join, please contact Bianca Viray in the Department of Mathematics.

Professional development roundtable: The informal roundtable discussions are held 6 times per semester at ICERM and cover issues ranging from job applications, the hiring process, paper writing, grant proposal writing to ethical conduct, and misconduct, in research. More information can be found at http://icerm.brown.edu/pds.

Sheridan Center: The Sheridan Center for Teaching and Learning provides many professional development workshops on teaching and other topics. It also provides various certificate programs for teaching assistants. For additional information, please go to the center’s website at http://www.brown.edu/Administration/Sheridan_Center/
CareerLab: The CareerLab provides individual confidential counseling sessions on job searches in industry (including feedback on resumes and CVs). Its website also provides a Doctoral Student Packet with useful and comprehensive information about all aspects of graduate-student life. See [http://brown.edu/campus-life/support/careerlab/](http://brown.edu/campus-life/support/careerlab/).

Graduate student wiki: The wiki [http://webapp.dam.brown.edu/wiki/WelcomePage](http://webapp.dam.brown.edu/wiki/WelcomePage), which is maintained by applied math graduate students, is another useful resource.

Useful links: The following links might be useful:

- Brown A-Z: [http://brown.edu/a-to-z/](http://brown.edu/a-to-z/)
- Banner (course registration): [https://selfservice.brown.edu](https://selfservice.brown.edu)
- Calendar: [http://www.brown.edu/Administration/Registrar/calendar.html](http://www.brown.edu/Administration/Registrar/calendar.html)
- For international students (OISSS): [http://brown.edu/Administration/OISSS/](http://brown.edu/Administration/OISSS/)
Formal Milestones and Requirements

Course Requirements

PhD students are required to enroll in, and successfully complete, 4 courses (or 3 if you are an RA or a TA) for credit per semester during their first 3 years (or 2 years if transferring in 8 semester courses). All courses taken for credit should be taken for a letter grade. Exceptions may be made for mandatory S/NC courses. In this case, the student should show a copy of the course description of the mandatory S/NC course to both the academic advisor and the DGS and obtain approval from both.

Independent research courses (APMA 2980) count toward these requirements—these courses can be enrolled in with variable credits so that they count for 1-3 “normal” courses. However, pre-prelim students should take at least 2 non-research-directed courses per semester.

You may not drop a class if it brings you below the 4 courses (or 3 if an RA or TA). Most students will therefore take 4 courses per semester in their first year, and 3 courses per semester during their second year when they are TAs. You should not take fewer than the required number of courses unless you receive permission from the Director of Graduate Studies.

Registration and grade options: You enroll in courses online through Banner. The relevant deadlines for registration, adding/changing/dropping courses, and for changing grade options (letter grade, satisfactory/no credit, or auditing) are posted on Brown’s calendar. The URLs for Banner and the Brown calendar are posted on the previous page.

PhD Candidacy and the Preliminary Examination ("the Prelim")

To become a PhD candidate, it is necessary to pass a preliminary oral examination. The preliminary examination may be taken at most twice.

Content: The prelim exam covers a major area with two topics and a minor area, comprising another two topics. Each topic covers the equivalent of at least two semester courses. Further requirements for the major and minor topics are discussed below. The major area is usually related to the student’s intended research area; the minor topics are meant to demonstrate breadth.

Format: The preliminary exam is an oral exam that is administered by an examination committee of four distinct faculty members, one for each topic. The preliminary examination committee is chaired by a faculty member, usually the student’s anticipated thesis advisor, who may, but does not need to, be one of the four examiners. The two major topics are examined during a 2-hour session, and the two minor topics in another 2-hour session. Each topic is examined for one hour. The two parts of the examination must take place within a two-week
period. Rare exceptions to this timing can only be made by the Director of Graduate Studies and then only for reasons of scheduling difficulties or unusual circumstances.

**Timelines:** Graduate students generally take the preliminary examination some time after the end of their first year and before the end of their second year of graduate studies unless exceptional circumstances prevent this. In most cases, the Chair of the preliminary exam committee continues to serve as the Thesis Advisor after the student passes the exam. If this is not the case, the student must find a Thesis Advisor within one month after passing the preliminary exam in order to be considered for support for the following academic year.

**Prelim proposals:** The proposed topics and examiners for the preliminary examination are prepared in consultation with and approved by the anticipated Thesis Advisor or another faculty member who agrees to be the Chair of the examination committee. The student should contact the four proposed examiners to get their approval and submit the prelim proposal to the Director of Graduate Studies for approval. The proposal must be submitted at least 2 months in advance before the expected date of examination. The proposed program should include the dates and times for the two exams, the names of potential examiners, the designated applied and theoretical topics, and detailed syllabi for any topics that relate to courses not taken at Brown. The necessary forms can be downloaded from the Division’s Google Site at [https://sites.google.com/a/brown.edu/applied-math/](https://sites.google.com/a/brown.edu/applied-math/).

**Eligible topics:** The major area should present a unified body of material that is viewed by the Director of Graduate Studies and the examiners as the main area needed for the student to conduct research in the chosen field. For instance, the two major topics may be based on two different aspects of the same subject area, such as theoretical and applied fluids or theoretical and computational numerical methods. In addition, the following aspects need to be considered:

- One of the four topics must be designated as an applied topic: most of the questioning for the applied topic will concern the scientific or engineering aspects of the subject.
- One of the four topics must be designated as a theoretical topic, in which the examination will concentrate on the mathematics of that topic.
- At least one of the minor topics must not be closely related to the major area.

The topics should be chosen from the following:

- Analysis (Real and Functional)
- Dynamical Systems
- Fluid Mechanics
- Numerical Analysis and Scientific Computation
- Pattern Theory and Statistics
- Partial Differential Equations
- Probability and Stochastic Processes
- Mathematical Methods (minor only)
• Outside minor from a department such as Biology, Computer Science, Economics, Engineering, Mathematics or Physics
• Additional topics not listed here can also be proposed, subject to the approval of the Director of Graduate Studies.

Note: In some cases, examiners may give the candidates written questions in addition to the oral examination. While the material covered in the examination is normally taken from course work, the examiners might ask new questions on the basic material or questions that integrate topics from several course areas.

Tips for preparing for the oral examination: For many graduate students, the prelim will be the first oral examination. As part of the preparation for the prelim, students may find it useful to get together in small groups and simulate oral exams: have one student stand at the blackboard and respond to questions by others in the group. This would help you get acquainted with oral examinations and reduce nervousness during the prelim itself. The process of preparing questions will also help you think about what is important in the material and what might be asked. If there are no other students who prepare for the same classes, ask (or bribe!) some of the more senior students to ask questions in an exam setup. Getting acquainted with answering questions on the spot is a very valuable skill that will prove very useful when you start giving talks or meet with other researchers to discuss mathematics.

Master of Science (ScM) Degree

Brown undergraduate and graduate students can enroll in our graduate program to earn an ScM in Applied Mathematics. Though the Division of Applied Mathematics does not have a professional Masters program, our instructional and research offerings afford rich possibilities for those who are preparing for careers in industry or government or who will seek teaching jobs that do not require the PhD, and who wish to improve their background in any of the various areas of applied mathematics.

To apply (for Brown undergraduate students): Please contact the Director of Graduate Studies via e-mail to set up an appointment -- bring an unofficial transcript and your proposed course plan to the meeting. Afterwards, apply to our Masters program through the Graduate School’s online application portal. The Division will contact you once your application has been processed.

To apply (for Brown graduate students): PhD students in the Division of Applied Mathematics automatically receive an ScM in Applied Mathematics once they satisfy the requirements for the ScM degree.

The new open graduate program allows Brown graduate students to also pursue a Masters in a different discipline, while they work on their PhD. Details can be found on the graduate school website: http://www.brown.edu/gradschool/opengraduateprogram.
Requirements for the Master of Science (ScM) degree in Applied Mathematics:

- A total of 8 courses must be satisfactorily completed; at least 6 of these must be Applied Mathematics (APMA) courses.
- At least 6 of the 8 courses must be taken at the 2000 level.
- A maximum of 2 C’s are allowed among the 8 courses.
- Research courses such as APMA 2980 and 2990 are not acceptable for fulfillment of requirements. However, topics courses are acceptable provided they meet regularly and have regular homework assignments and examinations.
- Courses taken S/NC (satisfactory/no credit) cannot be used for fulfillment of requirements.

Transferring courses (for Brown undergraduate students): With permission from the Director of Graduate Studies (DGS), one course (with a letter grade) can be transferred for credit from the undergraduate degree provided it has not been counted toward the undergraduate degree: students who wish to transfer a course should ask the Director of Undergraduate Studies to confirm, via an email to the DGS, that this course was not used for their undergraduate degree.

Doctoral Degree

The formal requirements for the PhD degree include the following:

1. Successful completion of twenty-four credits beyond the Bachelor's degree; research credits (APMA 2990) count towards this requirement (APMA 2990 can be taken for 1-3 credits per semester; all other semester courses count as 1 credit). A maximum of eight semester graduate courses can be transferred for students with course credit from other universities; we encourage students to talk to their Academic Advisor or Thesis Advisor, or to the Director of Graduate Studies about the suitability of transferring courses.
2. Every candidate for the PhD degree is required to serve as Teaching Assistant or Instructor for two semester courses.
3. Every candidate must write a dissertation that contains results of original research and gives evidence of high scholarship. The quality is assessed by the PhD Thesis Committee, which consists of the Thesis Advisor and two Readers.
4. Candidates shall present a public expository talk on the content of their dissertation.
5. Following the expository talk, there will be an oral final examination on the content and details of the dissertation. The final examination is conducted by the PhD Thesis Committee and is open to the faculty of the Division of Applied Mathematics.

Students must file their theses by May 1 in order to obtain the degree in that academic year.
Planning your graduate studies

Planning your courses

The course requirements for PhD students were outlined earlier in this document. There are no additional requirements for course selection, and you are encouraged to design your own course plan to fit your personal interests. However, in planning your course program, you are strongly advised to keep the preliminary examination requirements in mind as the prelims are largely based on the course work done in the first and second years.

Your Academic Advisor or your Thesis Advisor can help you develop your individual course program. A common and recommended program for the first year includes two two-semester course sequences from the following list of introductory courses, a sequence in the student's most probable major area, and another sequence in an area that is distinct from the preceding one and that is either a possible major or a minor area for the preliminary examination. You can also, as appropriate, take courses in other disciplines.

We regularly offer the following standard course sequences (detailed descriptions of these courses can be found on the Division’s website or on Banner):

- Real Analysis & Hilbert Spaces and their Applications (APMA 2110-2120 or Math 2210-2220)
- Nonlinear Dynamical Systems (APMA 2190-2200)
- Theory of Probability (APMA 2630-2640 or Math 2630-2640)
- Numerical Solution of Partial Differential Equations (APMA 2550-2560)
- Partial Differential Equations (APMA 2230-2240 or Math 2370-2380)
- Mathematical Statistics (APMA 2670-2680)

The department also offers many advanced topics courses with changing content that can be taken after the appropriate introductory courses have been taken. All courses except APMA 2210 can be taken only once; note that courses such as APMA 2570A and 2570B count as different courses.

Talks and Teas

In addition to taking courses, you are strongly encouraged to attend seminar and colloquium talks that are advertised on the Division’s website. Even though you may not understand everything that speakers say, these talks can give you a tremendous amount of information about current research trends and what research in individual mathematical areas looks like. Similarly, the Division of Applied Mathematics, the Department of Mathematics, and the Institute for Computational and Experimental Research in Mathematics (ICERM) regularly host workshops and conferences that you are encouraged to attend.
Finally, the weekly departmental teas on Thursday afternoon give you an opportunity to mingle with faculty and other graduate students.

**Planning for your research during years 1+2**

We encourage our pre-prelim graduate students to use the summer to work on research projects, pursue internships in industry or at national labs, or prepare for their preliminary exams. A particularly useful way of identifying possible thesis advisors and projects is to work with a faculty member over the summer on a research project: feel free to contact faculty members to inquire into opportunities. Your Academic Advisor and the Director of Graduate Studies can also help you in identifying such research and internship opportunities: the Division will host information sessions in late fall to assist in this process.

**Being a Teaching Assistant (TA) or Instructor**

Teaching is an important component of the training of our PhD students. Developing excellent communication skills and the ability to communicate technical and nontechnical content efficiently and effectively is crucial for all careers, whether in industry or in academia. Serving as a Teaching Assistant (TA) provides an excellent opportunity to develop these skills and is also a necessary prerequisite to teaching your own course as a sole instructor. Thus, we require that all our graduate students serve as TAs or instructors for at least two semester-long courses (exceptions are made only for students on certain federal fellowships that do not permit teaching of fellows). Serving as a TA is typically done during the second year.

**Duties as a Teaching Assistant**

A TA performs no more than 20 hours per week of teaching duties for an undergraduate course, or occasionally an introductory graduate course. The specific duties vary from course to course, but the minimum involves a total of four hours per week of recitation sessions and office hours. A significant amount of time is spent in preparing the course material, either by attending the lectures or by reading the textbook and handouts, before the recitation sessions and holding office hours. TAs may also be asked to grade homework assignments and exams and to prepare answer keys.

The Division asks graduate students for their preferences before finalizing TA assignments. TA workshops are sometimes held in late summer to prepare TAs. Some basic guidelines can also be found at [https://sites.google.com/a/brown.edu/applied-math/](https://sites.google.com/a/brown.edu/applied-math/). The Sheridan Center for Teaching and Learning also provides teaching workshops and various certificate programs for TAs. For more information, please go to the center’s website at [http://www.brown.edu/Administration/Sheridan_Center/](http://www.brown.edu/Administration/Sheridan_Center/).
Certification of students whose native language is not English

All foreign graduate students whose native language is not English must be certified by the Office of English for International Teaching Assistants as competent in oral English before being assigned to teach. If the evaluation reveals a need for supplementary training in oral English, the Center for Language Studies will help the student choose the most effective method to achieve competency. Thus, we require our first-year graduate students whose first language is not English to take the language evaluation no later than the end of their first semester. Information about this evaluation can be obtained through Jean Radican, the Senior Graduate Program Coordinator. If a student fails this evaluation, they will be required to take an English class in the second semester and take the evaluation exam again at the end of the second semester. Students who do not pass this evaluation may jeopardize their financial support.

Being an instructor

There are opportunities for graduate students who excel in their TA duties to teach their own courses as sole instructor. One option is to teach a course in the Summer@Brown program. Alternatively, the Division may need additional instructors for a course during the regular semester. Whether you want to teach in the summer or during the academic year, early planning is crucial as teaching assignments for the summer are finalized in late fall of the preceding year, whereas academic year (Fall and Spring) departmental teaching assignments are finalized in January of the preceding academic year.

The partnership of Brown with Tougaloo College, a historically black college in Jackson MS, provides another way of exploring life as a faculty member. The Brown-Tougaloo Faculty Fellowships allows advanced graduate students to spend a semester at Tougaloo College to teach and become immersed in faculty life. The deadlines for application are 15 October (for spring) and 15 February (for fall): more information can be found at http://www.brown.edu/Administration/Brown_Tougaloo/programs/Brown-TougalooFacultyFellowsProgram.html

Formal regulations and financial support

Academic standing

During early January and late May, the Director of Graduate Studies will collect feedback from faculty on each graduate student to identify any academic challenges or issues that arose during the preceding semester. Being in good academic standing requires the following:

- Years 1+2: completion of 4 (3 if RA or TA) courses per semester with satisfactory grades (all B’s or above, and with no more B’s than A’s);
- Year 2: identification, by the end of the second year, of a Thesis Advisor who has explicitly agreed to supervise the student’s thesis work;
• Prelim: passing both the major and minor preliminary exams by the end of the second summer of study;  
• Dissertation: completion of the dissertation within 6 years.

Failure to satisfy one or more of these criteria may lead to an academic warning, which is communicated to the student in writing together with a specific list of issues that need to be addressed to return to good standing. Graduate students put on academic warning are strongly encouraged to meet with their Academic or Thesis Advisor and with the Director of Graduate Studies.

Courses

All courses taken for credit should be taken for letter grade. Do not drop below the required 4 (3 if an RA or TA) courses per semester during your first two years.

Financial support

All PhD students are accepted with a guarantee of financial support for 5 years, including health fee, health insurance, and tuition. Financial support can be rescinded for students who are not in good academic standing and fail to address the issues that led to the academic warning.

In the case of an emergency, the Graduate School and the Office of Student Life each have a small pool of short-term loans available to help students.

Grievance procedure

Students should usually bring concerns or grievances directly to the attention of their Academic or Thesis Advisor or the instructor of the course if the issue is coursework related. If the outcome of this informal process is unsatisfactory, or if a student does not want to approach the advisor or instructor directly, they may bring the matter to the Director of Graduate Studies or the Department Chair, who will work with the student and faculty member toward a resolution. Beyond this, the University provides formal grievance procedures, which can be found in the Graduate School Student Handbook.

Leaves of absence

Leaves of Absence are granted for a variety of professional, educational, medical, psychological and personal reasons. They are granted for one semester or for one year, and may be extended to two years if necessary. The relevant procedures can be found in the Graduate School Student Handbook.
Office space

Every full-time Ph.D. student is assigned a desk in a shared office for graduate students. If a student wishes to change office location, please speak to Laura Leddy in Room 113. Priority is strictly based on seniority.

Travel support, and travel regulations

If you wish to attend a conference or travel to collaborate with others, please consult with your advisor for funding opportunities. Funding is also available on a competitive basis through the Graduate School:

- All graduate students are eligible to receive $500 per year to attend a conference at which they present: [http://www.brown.edu/academics/gradschool/conference-travel](http://www.brown.edu/academics/gradschool/conference-travel)
- Second to fifth (and some sixth) year PhD students can apply to obtain up to $1,800 of travel support on a 1:1 matching basis per year: application deadlines are once per quarter: [http://www.brown.edu/academics/gradschool/research-travel](http://www.brown.edu/academics/gradschool/research-travel)

More information about these opportunities can also be found in the Brown Graduate School handbook.

Another source of funding is the Office of International Affairs that provides partial funding for research and conference travel (this funding can be combined with funds obtained from the Graduate School). Details can be found at [http://www.brown.edu/about/administration/international-affairs/graduate-students](http://www.brown.edu/about/administration/international-affairs/graduate-students)

All graduate students on conference or research travel outside the US must register with the international SOS:

- [http://www.brown.edu/Administration/OIP/sojourn/](http://www.brown.edu/Administration/OIP/sojourn/)

Faculty

Below is a list of faculty and their areas of research. For more detailed information about faculty research, please refer to the home pages of individual faculty or talk with them directly. Office location, telephone numbers and e-mail addresses of faculty, staff, visitors and graduate students can be found within our website at [www.dam.brown.edu](http://www.dam.brown.edu)

List of faculty and their research areas

**Mark Ainsworth**: Numerical analysis, scientific computing, finite element and discontinuous Galerkin methods.
Elie Bienenstock (Applied Mathematics & Neuroscience): Theoretical neuroscience, artificial vision.

Constantine Dafermos: Continuum mechanics, differential equations.

Hongjie Dong: Partial differential equations, nonlinear elliptic and parabolic PDEs, Navier-Stokes equations, quasi-geostrophic equations, reaction diffusion equations, unique continuation problems, stochastic processes, numerical analysis.

Paul Dupuis: Stochastic control, probability theory.

Stuart Geman: Probability and statistics, natural and computer vision.

Basilis Gidas: Applied probability and statistics, computer vision, image and speech recognition.

Yan Guo: Partial differential equations, kinetic theory.

Johnny Guzmán: Numerical analysis of partial differential equations and scientific computing; local behavior of numerical methods; discontinuous Galerkin methods for second order elliptic problems, Stokes systems, singularly perturbed problems, conservation laws, and elasticity; hybridizable and mixed finite element methods; elliptic problems on non-smooth domains.


Jan Hesthaven: Numerical analysis, spectral high-order methods, scientific computing, computational electromagnetics, optics, and fluid dynamics.

George Karniadakis: Computational fluid dynamics, scientific computing, turbulence modeling.

Charles Lawrence: Computational molecular biology.

John Mallet-Paret: Differential equations, dynamical systems.


Govind Menon: Dynamical systems, partial differential equations, materials science.

Kavita Ramanan: Probability theory, stochastic processes and their applications, including large deviations, Markov random fields and phase transitions, and stochastic networks.

Björn Sandstede: Applied dynamical systems and partial differential equations, dynamics of patterns, coherent structures, and nonlinear waves.

Chi-Wang Shu: Numerical analysis, scientific computing, computational physics.


Hui Wang: Stochastic analysis and optimization, mathematical and computational finance, Monte Carlo simulation.

Courses

General basic courses

The general basic course sequence APMA 2110-2120 is taken mostly by our first-year or second-year students and is offered every year.

APMA 2110-2120

Real Analysis and Hilbert Spaces and Their Applications is a basic analysis sequence which provides required background for several other courses on differential equations, control theory, numerical analysis and probability, in particular for APMA 2190-2200, 2230-2240, 2630-2640, 2550-2560, and 2570. Most graduate students take this sequence, and use it as either a major or minor subject in their preliminary exams. Besides providing a necessary background for many other courses, this sequence also provides a good opportunity to encounter fundamental mathematical techniques and ideas.

APMA 2130-2140 [not offered regularly]

Methods of Applied Mathematics is the basic sequence in analytical methods of applied mathematics, specifically partial differential equations and integral equations. The background provided by this sequence is taken for granted in higher-level courses in PDE's, mechanics, numerical analysis, probability and mathematical statistics, and other branches of analysis. This sequence can be used in the preliminary exams as a topic in Applied Mathematics Methods, but only as a minor subject.]
Courses in different research areas

Other graduate courses can be loosely grouped into various research areas. However, this grouping is somewhat artificial, as many courses are applicable to multiple research areas. Some courses are not offered every year or may have a different course description, so please check the on-line Course Announcement (BANNER).

The descriptions below express the core elements of each individual course. The course descriptions in the BANNER listings may vary from year to year, depending upon the emphasis taught by individual faculty members.

Analysis

Students in analysis, ordinary and partial differential equations, and dynamical systems often take courses in this group to use as topics for the major in their preliminary exams. Students in other areas of research also often take these courses with the advice of their Academic Advisor or Thesis Advisor, sometimes to use them as topics for either the major or the minor in their preliminary exams.

APMA 2160 [not offered regularly]

APMA 2170 [not offered regularly]
*Functional Analysis and Applications.* Linear spaces, metric spaces, operators, contraction principle, fixed point theorems, linear functionals, adjoint spaces, spectral theory. Non-linear operators. Special spaces, and selected applications to differential equations, control theory, integral equations, quantum mechanics, and numerical analysis.

APMA 2190 - APMA 2200

APMA 2210
*Topics in Dynamical Systems.* Topics of interest in dynamical systems and ordinary, partial and functional differential equations.

APMA 2230 - APMA 2240
Partial Differential Equations. This sequence is also cross listed as Mathematics 2370-2380 and is taught by the faculty either from the Division of Applied Mathematics or from the Department of Mathematics. Distributions, Fourier transforms and Sobolev spaces. The Cauchy problem. Hilbert space methods, Elliptic boundary problems and regularity. Hyperbolic and parabolic systems. Semester I covers the basic linear theory. Semester II focuses on some special topic, usually nonlinear.

Mechanics

Students in mechanics and computational fluid dynamics often take courses in this group to use as topics for the major in their preliminary exams. Students in other areas of research also often take these courses with the advice of their Academic Advisor or Thesis Advisor, sometimes to use them as topics for either the major or the minor in their preliminary exams.

APMA 2410

Fluid Dynamics I. This course is cross listed as Engineering 2810 and is taught by a faculty member either from the Division of Applied Mathematics or from the Division of Engineering. Tensor notation. Thermodynamics. Eulerian and Lagrangian description of fluid motion. Conservation laws. Constitutive relations and irreversible processes. Initial and boundary conditions. Vorticity and Bernoulli theorems. Potential flow in two and three dimensions. Surface waves in a liquid.

APMA 2420

Fluid Dynamics II. This course is cross listed as Engineering 2820 and is taught by a faculty member either from the Division of Applied Mathematics or from the Division of Engineering. Dimensional analysis and similarity. Classification of flows according to dimensionless ratios. Exact, incompressible, viscous flow. Stokes and Oseen approximations and Stokes' formula. Boundary layer theory of the Blasius problem; hydrodynamic stability; inviscid theories; the Orr-Sommerfeld equation; qualitative theory of viscous instabilities. Turbulence. Compressible flow. Simple waves and shock waves. Sound propagation.

APMA 2470 - APMA 2480

Topics in Fluid Dynamics. Topics chosen from: Rarefied gas dynamics; Hydromagnetics; Non-Newtonian fluids; Stability Theory; Turbulence.

Numerical analysis and scientific computing

Students in numerical analysis and scientific computing often take courses in this group to use as topics for the major in their preliminary exams. Students in other areas of research also often take these courses with the advice of their Academic Advisor or Thesis Advisor, sometimes to use them as topics for either the major or the minor in their preliminary exams.

APMA 2550
**Numerical Solutions of Partial Differential Equations I.** Numerical techniques for the solution of time-dependent partial differential equations of mathematical physics. The course includes both theory and applications. Knowledge of computer programming is required.

**APMA 2560**


**APMA 2570**

*Numerical Solutions of Partial Differential Equations III.* Special Topics: finite element method, shock wave calculations, numerical linear algebra, spectral methods, parallel computing. Topics may vary from year to year. (APMA 2570A and APMA 2570B count as different courses).

**APMA 2580**

*Numerical Solutions of Partial Differential Equations IV.* An introduction of computational fluid dynamics with emphasis on incompressible flows.

**Probability, statistics and stochastic control**

Students in probability, statistics, bio-statistics, stochastic control, image processing and computer vision often take courses in this group to use as topics for the major in their preliminary exams. Students in other areas of research also often take these courses with the advice of their Academic Advisor or Thesis Advisor, sometimes to use them as topics for either the major or the minor in their preliminary exams. In addition to the courses below, students interested in applied statistics may wish to take courses offered by the Center for Statistical Sciences and Community Health (Biostatistics).

**APMA 2260**

*Introduction to Stochastic Control Theory.* Topics of current interest in the control of stochastic systems.

**APMA 2630 - APMA 2640**

*Theory of Probability.* A two-semester course in probability theory. Semester I includes an introduction to probability spaces and random variables, the theory of countable state Markov chains and renewable processes, laws of large numbers and the central limit theorems. Measure theory is first used near the end of the first semester (APMA 2110 may be taken concurrently). Semester II provides a rigorous mathematical
foundation to probability theory and covers conditional probabilities and expectations, limit theorems for sums of random variables, martingales, ergodic theory, Brownian motion and an introduction to stochastic process theory.

APMA 2660

*Stochastic Processes.* Topics in the theory of continuous parameter stochastic processes. The precise content varies from year to year, but generally includes many of the following topics: second order stationary processes, ergodic processes and their applications. Markov processes including jump processes and diffusions, applications to noise and communication theory. Prerequisite: APMA 2640.

APMA 2670

*Mathematical Statistics I (Statistical Inference).* This course presents a comprehensive account of the theoretical aspects of modern statistical methods. Topics include: exponential families, sufficiency and completeness, frequentist point and interval estimation, unbiasedness, maximum likelihood estimation and large sample methods, Bayesian inference, hypothesis testing, and non-parametric inference. Recent advances in computational approaches will also be discussed. Prerequisites: Background in multivariate calculus and introductory probability theory.

APMA 2680

*Mathematical Statistics II.* Introduction to decision and game theories; admissibility; complete class theorems; the Bayesian approach to statistics; subjective and prior information; posterior distribution; Bayesian methods for point estimation, hypothesis testing, and multiple decision problems; Bayesian sequential analysis; the sequential likelihood tests; applications to classification and learning problems. Prerequisite: APMA 2670.

APMA 2690 - APMA 2700

*Topics in Statistics and its Applications.* Advanced topics varying from year to year, including: non-parametric methods for density estimation, regression and prediction in time-series; cross-validation and adaptive smoothing techniques; bootstrap; recursive partitioning projection - pursuit, ACE algorithm; non-parametric classification and clustering; stochastic Metropolis-type simulation and global optimization algorithms; Markov random fields and statistical mechanics; applications to image processing, speech recognition and neural networks.

Advanced seminar courses

APMA 2810 and APMA 2820, Seminars in Applied Mathematics, are seminar courses with topics varying from year to year. Please refer to the current on-line course announcement (BANNER)

Courses in other departments
There are many courses in other departments, such as in computer science, engineering, geology, mathematics, neuroscience and physics, which are suitable for our graduate students to take. These courses are either related to the research or applicable as a minor subject in the preliminary exams, or both. Please check the current on-line course announcement (BANNER) and discuss with your Academic Advisor or Thesis Advisor the suitability of any such courses.

**Undergraduate courses**

Occasionally there are undergraduate (1000 level) courses which may be suitable for our graduate students. Please check the current on-line course announcement (BANNER) and discuss with your Academic Advisor or Thesis Advisor the suitability of any such courses.