

Navigating the CMS PhD Option

This document gives an overview of the typical student path through the CMS Ph.D. program. Note that it is not a replacement for discussions with your faculty advisor or for the information in the Caltech Catalog, which lists the official degree requirements. Rather, this document is meant to outline the typical progression students make through the degree.

Overview of the CMS requirements

The CMS requirements basically fall into two categories: coursework and exams. The coursework consists of a set of core courses that all CMS students take together during their first year, followed by a set of elective courses meant to encourage breadth & depth of knowledge. Beyond the coursework, students have three exams: a **preliminary exam** during the first year, a **candidacy exam** during the 2nd or 3rd year, and a **thesis defense**. Additionally, all students are required to attend the CMS colloquium regularly.

The typical progression through the program is outlined in the following. Note that at the end of each year, students receive **progress letters** from the faculty evaluating progress toward the PhD so far and outlining hurdles for the coming year. More detail about these letters is included below.

What to expect during year 1

The goal for the first year of the program is to ensure that students get started on research and build a basic core knowledge across CS, EE, and Applied Math. So, during the first year, students focus on three things: (1) finding a research adviser, (2) completing the “core” classes and (3) passing the preliminary exam.

Finding an adviser

Most students have an idea of 1-2+ possible research advisers before arriving at Caltech. Thus, the task for the first year is to attend the group meetings of these multiple possible advisers, talk to their students, and (of course) meet with them and discuss possible research projects, etc. Most typically, students find a strong match with an adviser during the first or second term, and have already begun working on an initial project by the time the third term begins. It is also common for students to work with multiple faculty members throughout the first year, and even beyond.

During the first year you should expect to

- do lots of reading (papers & books).
- do lots of presentations in 1-on-1 meetings and in group meetings
- work on some very specific open research questions to get your hands dirty
- do lots of talking about open problems in the area so that you can start to determine your own research direction

Note that the goal is to know your field by the end of the year, so you need to learn a lot and learn it thoroughly. As a result, the focus is not on publications (yet)!

You should also make sure to spend time getting to know many of the CMS faculty & students (not just your adviser and lab mates).

The core classes

The core classes include three courses during the fall and winter terms. The fall term is focused on mathematical fundamentals and the winter is focused on computing fundamentals. The spring term is then open for research and topics courses.

Fall core classes: Mathematical Fundamentals

- CMS/ACM 104. Linear Algebra & Applied Operator Theory
- CMS/ACM 113. Mathematical Optimization
- CMS/ACM 116. Introduction to Stochastic Processes

Winter core classes: Computing Fundamentals

- CMS/CS 139. Analysis & Design of Algorithms
- CMS/CS/EE 144. Networks: Structure & Economics
- CMS/CS 155. Machine Learning & Data Mining

All CMS students take each of these classes together during the first year. While some students will be occasionally be allowed to pass out of some of the courses if they have taken equivalent courses during their undergraduate programs, it is quite rare since these are unique courses to Caltech. Talk to the option representative if you would like to discuss placement out of one of these core classes.

Depending on student and adviser wishes, students may choose to take additional courses beyond the core courses during their first two terms, but this is not necessary. Students wishing to get started quickly on research should likely not take more than 1-2 courses beyond the core during the first two terms.

Preliminary exam

The preliminary exam occurs during the first week of the spring term. The purpose of the exam is to evaluate expertise in the topics included in the core courses listed above. The exam consists of modules related to each of the six core classes. Students are to choose 2 courses from the fall term and 2 courses from the winter term to be examined on. This choice is made *before* seeing the exam.

For additional information about potential subject matter, you should feel free to discuss relevant references, etc. with members of the faculty; however, do not expect the questions to be derived from any specific reference. Also, do not expect (or ask for) information about the nature or topics of the questions themselves.

Format of the exam

Two and one-half (2-1/2) hours are allotted to the exam. During the first 90 minutes you will be given a written copy of the exam questions, and will have the opportunity to prepare your answers; during the final 60 minutes you will answer the questions orally at the direction of the committee. While preparing your answers, you are not allowed to consult references of any kind. All information that we do not expect you to know (or be able to derive) will be supplied as part of the question. You should strive to present your answers in a concise and incisive manner. Due to scheduling, we will not be able to extend the answer period beyond 60 minutes.

Exam scheduling

The Preliminary Exam will take place during the first week of the third term in residence. All first-year CMS students will receive a scheduling form during the second term, which must be filled

out and returned to the Option Administrator no later than the end of second term (i.e., the last day of classes).

The schedule for exams will be available by the end of finals during the second term, and exams will normally be scheduled at the end of the first week of the third term. The results of the exam will be announced after all students have completed the exam.

Exam Outcomes

Four types of decisions are possible: *pass*, *conditional pass*, *partial retake*, *full retake*. A student with a *pass* or *conditional pass* is permitted to begin his or her Ph.D. research. However, a student with a *conditional pass* will usually be required to satisfy some additional requirements, such as successful completion of specified coursework or TA a course to obtain further background. Students who are asked to do a full or partial retake will retake some or all of the subject exams at the beginning of the summer term. It is not unusual for students to have to retake one or more of the subjects -- nearly 50% of students have at least a partial retake after the first exam. The format of the retake is the same as for the initial exam, except only a subset of the areas are examined. Three types of decisions are possible for the retake: *pass*, *conditional pass*, *fail*.

Budget for computing

One of the first things you'll likely want to do when you arrive is buy a desktop/laptop. For this purpose, every CMS student is budgeted \$2000 to spend however on computing related equipment, e.g., desktop, laptop, monitor, ergo keyboard, presentation clicker, etc. This \$2000 can be spent anytime while at Caltech. Once it runs out, you should coordinate with your adviser regarding additional purchases. If you are unsure what computer would be most appropriate, we recommend chatting with your possible advisers as well as other students in the department. Of course, please save all receipts and submit them to either your adviser's admin or Maria Lopez.

What to expect during years 2-3

During the second and third year, students are typically beginning to pursue independent research in earnest. Students must have settled on a primary adviser before the second year, though many continue to work with multiple faculty throughout their second and third years.

Students typically finish their Depth and Breadth course requirements during their second year, and these should certainly be finished before the end of the third year. These are described below. The largest hurdle for during this period is the candidacy exam, which is required to be completed by the end of the third year.

Depth & Breadth Requirements

The courses students take during the 2nd and 3rd years are meant to provide both depth into their proposed research area and breadth across CMS related areas. Both of these requirements are extremely flexible.

For the *breadth* requirement students must complete 27 units of 100+ level courses in Engineering, Science, Mathematics, or Economics. These can really be almost anything and are meant to provide expertise in topics beyond the core research focus.

For the *depth* requirement students must complete 27 units of courses within one particular subject area. The plan for these 27 units should be discussed and approved by the student's adviser. Example focus areas include:

- Algorithms & complexity: Approximation algorithms, online algorithms, complexity theory, and computability.
- Algorithmic economics: Auctions and mechanism design, algorithmic game theory, and privacy.
- Biological circuits: Organic substrates for computation, including neuronal computing and DNA computing.
- Feedback & control: Robust control, feedback, dynamical systems theory.
- Inference & statistics: Statistical decision theory, information theory, and adaptive signal processing.
- Information systems: Information theory, coding theory, communication, and signal processing.
- Machine learning & vision: Algorithmic, mathematical, and biological perspectives on computational models for learning and vision.
- Networked systems: The study of complex networks, in fields ranging from biology, social science, communications, and power.
- Optimization: Convex optimization, conic and discrete optimization, and numerical methods for large-scale optimization.
- Quantum information theory: Quantum algorithms and complexity, convex optimization, and operator theory.
- Scientific computing: Computational methods for problems arising in the physical sciences, partial differential equations.
- Uncertainty quantification: Markov chains and martingales, stochastic system analysis, and convex optimization.

Candidacy Exam

All students must pass a candidacy oral examination, which will be administered by a committee that consists of four faculty, is approved by the option representative, and is chaired by the student's research adviser. The committee must include at least three Caltech faculty and at least two CMS faculty.

The examination will ascertain the student's breadth and depth of preparation for research in the chosen area. Prior to the candidacy exam the student must submit a Research Progress Report to the committee, as detailed below.

CMS students are encouraged to complete the Candidacy Examination by the end of their second academic year at Caltech, and must have completed it by the end of their third year. A student who fails to satisfy the requirements of the Division for candidacy by the end of the third term of the third year in residence at the California Institute of Technology will not be allowed to register in a subsequent academic year except by special permission of the Division.

The procedures for scheduling and taking the exam are as follows.

1. Select a tentative date (determined by the candidate and his or her research adviser) and an examining committee of at least four members (including the adviser). Check with the CMS option administrator to avoid time/place conflicts. Then, check with members of your committee to see that the date is satisfactory. The committee must be approved by the Option Representative before the exam is scheduled.

2. Go to the Graduate Degree Progress and select the Ph.D. Candidacy Tab. Please complete your Plan of Study. If you choose to pursue a minor, please see CMS option administrator Maria Lopez.

3. Prepare a Research Progress Report and deliver an electronic or printed copy to each of your committee members no later than *two weeks* prior to your oral examination. This report should concisely state your progress to date, your proposed research topic, and the nature of the contribution which you expect to make in the general problem area. It should also include one piece of original research, e.g., a published paper or preprint. A typical format is a 2-5 page research overview followed by an attached paper.

4. The oral examination will consist of a public 50 minute presentation followed by a closed-door examination of the candidate by the committee. The presentation should include an overview of the general research area, a description of (at least) one piece of original research, and a proposed research direction.

5. Once the Candidacy Examination is completed satisfactorily, the members of the examining committee will approve in the Graduate Degree Progress system. You will be notified later by the Dean of Graduate Studies that you have been admitted to Candidacy for the Degree of Doctor of Philosophy.

What to expect during years 4-6

Following the candidacy examination, students focus on their Ph.D. dissertation research. Typically students graduate in five years, though some take less/more time.

During this period, each student will form a thesis committee (possibly the same as the candidacy committee) consisting of at least four faculty approved by the option representative, and chaired by the adviser. The thesis committee will meet as needed, but at least yearly, in order to advise the student.

The final hurdle is, of course, the Ph.D. defense. A final oral examination will be scheduled and given after the PhD thesis has been submitted for review to the student's adviser and thesis committee. The thesis examination is a defense of the thesis research and a test of the candidate's knowledge in his or her specialized fields. Normally, the defense will consist of a one-hour public lecture followed by an examination of the thesis by the thesis committee.

Procedures for Processing Necessary Forms

1. At least *three weeks* prior to the exam date, obtain the following forms from the Graduate Office:
 - Petition for Exam
 - Application for Approval of Thesis

2. The date of the Ph.D. exam and the committee members will be determined by you and your research adviser and must be approved by the Option Representative. The committee must include at least four members, at least three of which are Caltech faculty and at least two of which are CMS faculty. Check with members of your committee for agreement on the date and time of the exam. Once a definite date and committee are set. Login to Graduate Degree Progress (Ph.D. Tab) and complete Examination Committee. The Graduate Degree Progress System will send a confirming memo to the committee members.

3. All committee members will approve

Procedures for Submitting the Ph.D. Thesis

1. *At least two weeks prior to your exam*, supply each member (four are needed, one of whom can be a qualified Ph.D. from off-campus) of your committee with a copy of your thesis. If corrections or revisions are required, it is your responsibility to:
 - make the necessary corrections or revisions;
 - submit the revised thesis to members of your examining committee; and
 - all committee members will approve via Graduate Degree Progress
 - final approval will be done by your advisor on the Graduate Degree Progress System. Once the acceptance of the corrections or revisions.
2. Submit one copy of your thesis to the Graduate Office for proofreading. This should be done at the same time the thesis is submitted to your committee members. (If corrections or revisions are required, the thesis must be proofread a second time.) You will be notified as soon as the proofreading is complete (usually a couple of days).
3. Submit *two corrected copies* of the thesis to the Graduate Office: one copy must be on Perma-Life or Old Council Tree bond paper, reproduced from the original; the other copy may be regular Xerox paper (see Graphic Arts for further information). Submit these copies in a brown envelope labeled as follows: your name, Ph.D.; Control and Dynamical Systems; year. Also submit two extra title pages and two extra abstracts.

To assist you in preparing for your final Ph.D. Examination, you should obtain the following publications from the Graduate Office:

- "Preparation of Doctoral Dissertations" and
- "Ph.D. Examination Procedures"

Progress Letters

All CMS students will receive yearly progress letters at the end of the spring term. These letters are a crucial source of feedback and advice for students (and their advisors).

To prepare these letters all CMS faculty meet and discuss each student individually -- considering progress and performance in courses and research. Then, a letter is composed to the student to provide details feedback on their performance as well as advice for the coming year.

Before the faculty meeting (typically early in the spring term), each student is asked to submit a summary of their accomplishments during the year so that these can be brought up during the faculty discussion.

CMS Colloquium

The CMS colloquium is a student-run seminar series that brings in well-known academic and industry speakers from across CS, ACM, EE, and CDS. **All students in the CMS department are required to attend.**

The colloquium is run by a committee of students chosen from all the PhD options in the CMS department. The committee meets over the summer to decide on a list of speakers to invite. Then, for each invited speaker, the committee should arrange a faculty host (to take the speaker to dinner) and then arrange a meeting schedule for the speaker during their visit,

including both student and faculty meetings. The administrative staff will help with travel and scheduling arrangements.

If you would like to serve on the colloquium committee, please let your faculty adviser know. Membership will rotate yearly among interested students.

Other Important info for getting started at Caltech

Acronyms

ACM – Applied and Computational Mathematics

CDS – Control and Dynamical Systems

CMI – Center for mathematics of information (CS/EE theory center)

CMS – Computing and Mathematical Sciences (it's both a department and an option)

IQIM -- Institute for Quantum Information and Matter

IST – Information sciences and technology (broad umbrella center housing EE & CMS)

RSRG – Rigorous Systems Research Group (CS Networking/Systems group)

SISL – Social and information sciences laboratory (CS/Econ center)

Related Seminars

CMS colloquium: Mondays 4:15-5 pm. Main seminar for CMS visitors, always has good talks. Email "Sydney Garstang" <sydney@caltech.edu> to get on the mailing list.

Lunch Bunch: IST's main seminar series. Tuesday's over lunch 12-1. (Get there early to get food since it goes fast.) General audience talks by very invited speakers from both academia and industry. Email "Sydney Garstang" <sydney@caltech.edu> to get on the mailing list.

CMI seminars: Most Tuesdays 4-5 pm. 2-lectures series by postdocs introducing their area (1st lecture) and their work (2nd lecture) in detail. Subscribe to CMI announcement list www.cmi.caltech.edu/links.shtml

CDS seminars: These seminars are not at a regular time, but happen throughout the year whenever someone is passing through. If you would like to get announcements for these seminars, send e-mail to Richard Murray <murray@cds.caltech.edu> to be added to the cds-all mailing list.

Econ theory seminars (the Bray Theory Workshop): Wednesdays 4pm-5pm in Baxter 25 (basement) with refreshments afterward in Baxter 3rd floor. Contact Barbara Estrada bestrada@hss.caltech.edu at 626.395.4083.

SISL seminars: Most Fridays over 12-1. Focus is on the intersection of CS and economics. There are a mixture of student presentations about their work and visitor presentations. Email "Barbara Estrada" <bestrada@hss.caltech.edu> to get on the mailing list.

Also fun are the Political Economy seminar (Tuesdays; works the same as the Econ theory ones) and the Behavioral Social Neuroscience Seminar (Thursdays; also same setup). All upcoming HSS seminars may be found on the web at <http://www.hss.caltech.edu/seminars>.

Email "Gail Nash" <gnash@hss.caltech.edu> to get added to the hss-seminar mailing list. If you have icalendar software, such as iCal, Outlook, or Google calendar, you may subscribe to the seminar calendar at webcal://www.hss.caltech.edu/~hssbot/Seminars.ics

Relevant mailing lists

Annenberg building list: Email "Jeri Chittum" <jeri@cms.caltech.edu>

Control and Dynamic Systems list: go to http://www.cds.caltech.edu/ mailing_lists

International students list: you should be added automatically, <http://international.caltech.edu/>

CMS seminars: Email "Sydney Garstang" <sydney@caltech.edu> to get added to the list
RSRG mailing list: Email "Sydney Garstang" <sydney@caltech.edu> to get added to the list

Who to ask for what

Initial procedural details & administrative questions: "Maria Lopez" <mlopez@cms.caltech.edu>
Office/Building related: "Jeri Chittum" <jeri@cms.caltech.edu>

Procedures for Exceptional Circumstances

Transferring into CMS from Another Option

Students wishing to switch into CMS from another option must do so before the end of their second year of residence at Caltech. Students must satisfy all option course requirements and must pass the candidacy exam in order to be officially admitted into the CMS Ph.D. program. In addition, the student is typically expected to take the CMS preliminary exam no later than the first year of study after transferring into the CMS option. Exceptions can be made in some situations, such as switching options within the CMS department.

The procedure for switching into CMS is as follows:

1. The student should submit a written request to the Option Representative to consider admission into the CMS option. Under normal circumstances, this request must be received no later than the admissions deadline for incoming graduate students (typically mid-December).
2. The Admissions Committee will consider applications for transfer using the same criteria as outside admission into the CMS program. Transfer students will be notified of admission by the usual admissions response deadline (typically mid-March).
3. Transfer students who are admitted into CMS must accept or decline admission no later than the usual admissions deadline (typically April 15). If admitted, the student may either transfer immediately or defer admission until the beginning of the academic year.
4. Financial aid for transfer students will be described in the letter of admission. Aid is not usually available until the beginning of the next academic year.

Receiving a M.S. Degree

Students are admitted to the option under the expectation that they will pursue the Ph.D. degree. However, a M.S. degree may be awarded in exceptional cases.

The M.S. degree, unlike the Ph.D., is based primarily upon the successful completion of coursework. This coursework must include at least 135 units in order to satisfy Institute requirements, and must include courses satisfying course requirements of the CMS Ph.D. degree. Additionally, a candidacy committee must recommend the awarding of the degree.

All M.S. students are required to submit candidacy forms to the Institute for approval of the proposed course of study for the M.S. degree. The M.S. candidacy form must be submitted by midterm (approximately mid-November) of the first term of the year when the degree is expected. These forms can be obtained at the Institute Graduate Office.