CTP Guidelines for Graduate Students

Fall 2020

These are the guidelines for the typical progression of a graduate student in the CTP, which should lead to a PhD within 5 years. Students in the Center for Theoretical Physics (CTP) should always be in close contact with their **academic advisor**, even more so before they join a research group. You should also consult the Department's PhD guidelines here

http://web.mit.edu/physics/current/graduate/doctoral.html

and be in contact with the Department's Academic Programs office should you have questions/concerns going forward.

As appropriate, the information below is divided into two cases, one for nuclear & particle theory students and one for theory students in quantum information. If not specified, the information applies to both groups.

Typical Timeline (Nuclear or Particle theory):

First Year (N&P):

Students often have a fellowship their first year, in which case no teaching is required.

1. Fall:
   - Take written exams (*strongly* recommended).
   - Depending on preparation, either take Quantum Field Theory II (8.324) at MIT, or else take QFT 1 at Harvard, or Quantum Theory I (8.321) at MIT.
   - Take one breadth class.
   - Take classes to cover written exams (8.309 for Classical Mechanics, 8.321 for Quantum Mechanics, 8.333 for Statistical Mechanics).
   - Attend seminars, meet fellow graduate students, postdocs and faculty in the Department.
2. Spring:
   - In January, must take written exams for any parts not yet passed; can take 8.311 for Electromagnetism during spring term.
   - If prepared, take QFT III (8.325) at MIT. Otherwise take QFT I (8.323) at MIT or maybe QFT 2 at Harvard. If taking QFT 3, maybe also listen to QFT 1 at MIT, or QFT 2 at Harvard.
   - Take breadth class.
   - Meet with potential PhD research advisors.

- Prepare research project for summer with one or more research supervisors.

3. Summer:
    - Start research project.
    - Study for written exam if you still have some subjects to take.

Second Year (N&P):

1. Fall:
    - Take written exam if needed.
    - Take QFT 2 at MIT if needed.
    - If ready, think about taking oral exam.
    - Work on research, TA if required
2. Spring:
    - Take QFT 3 at MIT if needed
    - Take oral exam if possible, TA if required
    - Work on research, hopefully by now you have established a research advisor
3. Summer:
    - RESEARCH.

Third Year (N&P):

1. Fall:
    - You must take your first attempt of the oral exam if you have not already done so.
    - Finish any required classes you might have left.
    - Work on research, TA if required
2. Spring/Summer:
    - Second and final opportunity to pass oral exam, if needed.
    - If oral exam passed in fall, submit thesis proposal form to APO, form thesis committee
    - Hold first thesis committee meeting.
    - Research full time, TA if required
3. Take breadth or optional special topics courses as desired from here on

Fourth Year (N&P):

1. Fall:
    - If oral exam completed in spring of third year, submit thesis proposal form to APO, form thesis committee
    - Hold first thesis committee meeting.
    - TA if required
2. Spring/Summer:
    - If applying for postdocs, the bulk of your research portfolio should be built by the end of the summer. Be mindful that some postdoc positions have early (August or early September) deadlines, for eg. CERN and certain advisor nominated fellowships.
    - TA if required
    - Confirm with APO that you have no remaining specialty or breadth subjects to complete

Fifth Year (N&P):

1. Fall:
    - Submit postdoc applications if planning on staying in academia.
    - TA if required
2. Spring:
    - Write thesis, TA if required
    - Must finish any missing breadth or specialty courses (hopefully they are already done)
    - Thesis defense
    - GRADUATE!

Students should expect to graduate in their fifth year. Should circumstances arise that may affect this time frame, the student needs to discuss the matter with their research advisor and Scott Morley.

Classes (Nuclear and Particle theory):

Please refer to the Department web sites on PhD requirements, but classes required in the CTP are:

- QFT 3 at MIT
- Two additional specialty (specialty = depth) classes, most often satisfied by selecting two from the following list:

  8.334 Statistical Mechanics II
  8.821 String Theory
  8.831 Supersymmetric Quantum Field Theory
  8.841 Electroweak Interactions
  8.851 Effective Field Theory
  8.701 Intro to Nuclear and Particle Physics
  8.952 Particle Physics of the Early Universe
  8.962 General Relativity

  Several of these courses are only offered every two or three years, including 8.821, 8.831, 8.841, 8.851, and 8.952. The course 8.701 is most often taught by an experimental nuclear or particle physicist, and hence is a good way for theorists to get exposure to an experimental point of view. Other special topics courses relevant for CTP students are also occasionally offered, and can be used to satisfy a specialty requirement with permission from a student's academic advisor, and subsequent approval by the CTP director.
- Two breadth classes: Breadth courses are intended to provide a broad introduction to a field other than the student's specialty. Subjects that are designed for specialists in an area are not appropriate for the breadth requirement. Possible courses include Quantum Computation, Astro I or II (I is not a prerequisite for II, despite what the course catalog says), Theory of Solids I, Plasma Physics, a Biophysics course, or Atomic & Optical physics I or II. Courses not on the list can be approved with permission of your academic supervisor, and the department's General Exam and Requirements Coordinator; if you have any questions about the process for requesting a substitution, be sure to check with the Academic Programs Office request.

The full academic responsibilities for graduate students are discussed in greater detail on the main Physics website (http://web.mit.edu/physics/current/graduate/doctoral.html), which includes the full list of pre-approved suitable breadth courses. Students are encouraged to visit the website for more information about the course requirements.

Oral Qualifying Exam (Nuclear and Particle theory):

Nuclear and Particle Theory (NUPAT) students, like all students in the Physics Department, are required to pass an oral examination in their subfield. The first attempt at the oral exam must be taken by the end of the first term of the third year. Two attempts are permitted, with the second attempt scheduled in the subsequent term. If the subsequent term precedes the third year, a student may postpone the second attempt until the beginning of the third year.

The exam is administered by the Oral Exam Committee, composed of three faculty members. Should the student's research advisor be a member of that committee, another faculty member will be substituted in place of the advisor.

The exams are scheduled at the beginning of the Fall or Spring term and will take place in December and May, respectively. The NUPAT oral exam consists of two parts:

(1) A short exposition on a question or topic assigned to the student by the Head of the Oral Committee no later than two weeks before the exam.

(2) A set of questions on theoretical nuclear and particle physics posed by the committee.

Passing of the exam will depend on the student's performance in the assigned question, as well as his or her proficiency in ***theoretical nuclear physics*** **and** ***theoretical particle physic*****s.** The topics and questions are drawn primarily from material covered in NUPAT graduate classes, with emphasis on 8.325 and Field Theory of the Standard Model. If you have a question about whether some particular material should be studied for the exam, then you should ask the current head of the NUPAT Oral Exam committee.

The exam is most often 120 minutes in duration and results are communicated to the student at the completion of the exam.

Furthermore, please note that more senior CTP students have a list of suggested books, material, and a shared Dropbox with previous questions that is helpful for studying. Additional suggestions:

1. Students are encouraged to form study groups for the oral exam. It is an excellent way to learn.
2. Students should talk to more senior graduate students about what the exam has covered in past years, and consult the above-mentioned documents.
3. Talk to your committee before taking your exam to discuss your topic and any suggested material.
4. Ask faculty if you have questions. If they have time, they are always happy to help.

Typical Timeline (Quantum Information):

First Year (QI):

Students often have a fellowship their first year, in which case no teaching is required.

1. Fall:
   - Take written exams (*strongly* recommended).

- Consider taking or TAing 8.370. Other helpful classes can be 8.511 (Theory of Solids 1) or 6.840 or 6.841 (Computational Complexity Theory 1 or 2).
- Take breadth class.
- Take classes that satisfy written exams (8.309 for Classical Mechanics, 8.321 for Quantum Mechanics, 8.333 for Statistical Mechanics).
- Attend seminars, meet fellow graduate students, postdocs and faculty in the Department.
- Plan to attend QIP conference, usually in January.

2. Spring:
   - In January, must take written exams for any parts not yet passed; can take 8.311 for Electromagnetism in the spring term.
   - Take 8.371 (Quantum Information Science II).
   - Take breadth class. Other helpful classes can be 8.323 (QFT 1), 8.334 (Stat Mech 2), 8.421 or 8.422 (AMO 1 or 2), 8.511 (Theory of Solids 2), 6.437 (Inference and Information), 6.842 (Randomness and computing).
   - Meet with potential PhD research advisors.
   - Prepare research project for summer with one or more research supervisors.
3. Summer:
   - Start research project.
   - Study for written exam if you still have some subjects to take.

Second Year (QI):

See year 1 for class suggestions beyond 8.371.

4. Fall:
   - Take 8.S372/18.S996 (QIS 3).
   - Take written exam if needed.
   - If ready, think about taking oral exam.
   - Work on research, TA if required.
5. Spring:
   - Take oral exam if possible, TA if required.
   - Work on research, hopefully by now you have established a research advisor.
6. Summer:
   - RESEARCH.

Third Year (QI):

3. Fall:
   - You must make your first attempt of the oral exam if you have not already done so.
   - Finish any required specialty or breadth classes you might have left.
   - Work on research, TA if required.
4. Spring/Summer:
   - Final opportunity to pass oral exam.
   - Research full time, TA if required.

3. Take breadth or optional special topics courses as desired from here on.

Fourth Year (QI):

3. Fall:
    - Form thesis committee, submit thesis proposal form to the department
    - Hold first thesis committee meeting.
    - TA if required

4. Spring/Summer:
    - If applying for postdocs, the bulk of your research portfolio should be built by the end of the summer. Be mindful that some postdoc positions have early (August or early September) deadlines, for example, certain advisor nominated fellowships.
    - TA if required

Fifth Year (QI):

3. Fall:
    - Submit postdoc applications if planning on staying in academia.
    - TA if required
4. Spring:
    - Write thesis, TA if required
    - Must finish any missing breadth or specialty courses (hopefully they are already done)
    - Thesis defense
    - GRADUATE!

Students should expect to graduate in their fifth year. Should circumstances arise that may affect this time frame, the student needs to discuss the matter with their research advisor and Scott Morley.

Classes (Quantum Information):

8.370 (QIS 1) is too basic for most QI grad students, but might be appropriate for someone transferring into the field from another area.

8.371 (QIS 2) should be taken as early as possible by any grad student specializing in QI.

8.S372/18.S996 (QIS 3).

6.S979 Quantum Nonlocality, taught by Anand Natarajan.

Another possibility is Harvard's Physics 271, often taught by Misha Lukin, but it will repeat many of the topics appearing in 8.371.

Additional advanced QI classes may be offered in the future.

Since there are few dedicated QI grad courses, students should learn broadly about related topics in physics and computer science (CS). Physics classes could be on condensed-matter theory, AMO, QFT or holography. CS classes could be on algorithms, randomness, information theory, or complexity theory.

Oral Qualifying Exam (Quantum Information):

Quantum Information (QI) students, like all students in the Physics Department, are required to pass an oral examination in their subfield. The first attempt at the oral exam must be taken by the end of the first term of the third year. Two attempts are permitted, with the second attempt scheduled in the subsequent term. If the subsequent term precedes the third year, a student may postpone the second attempt until the beginning of the third year.

The exam is administered by the Oral Exam Committee, composed of three faculty members. Should the student's research advisor be a member of that committee, another faculty member will be substituted in place of the advisor.

The exams are scheduled at the beginning of the Fall or Spring term and will take place in December and May, respectively. The QI oral exam consists of two parts:

(1) A short exposition on a question or topic assigned to the student by the Head of the Oral Committee no later than two weeks before the exam.

(2) A set of questions on quantum computing and quantum information posed by the committee.

Passing of the exam will depend on the student's performance in the assigned question, as well as his or her proficiency in ***quantum computing and quantum information.*** The topics and questions are drawn primarily from material covered in the textbook by Nielsen and Chuang.

The exam is up to 120 minutes in duration and results are communicated to the student at the completion of the exam. Additional suggestions for preparation:

1. Students are encouraged to form study groups for the oral exam. During these groups, take turns acting as examiners and coming up with questions. It is an excellent way to study.
2. Students should talk to more senior graduate students about what the exam has covered in past years.
3. Talk to your committee before taking your exam to discuss your topic and any suggested material.
4. Ask faculty if you have questions. If they have time, they are always happy to help.

Teaching:

The CTP tries to support students with at least two RA's out of the 8 semesters from years two through five. The number of RA semesters may vary depending on your advisor and you should discuss this with them early on. In the non-RA terms, students are required to teach. Students are strongly urged to apply for external fellowships early in their time at the CTP (see below).

Travel (When travel is again allowed by MIT):

At the CTP, advanced students can receive $500 domestic a year towards travel for conferences or summer schools ($1000 for international travel). If your travel exceeds this amount, ask your advisor if they are able to cover some of the costs. See separate literature for Graduate Student Travel Program (obtain from Joyce Berggren, Scott Morley or Charles Suggs).

Additional funding is possible from GSC (http://gsc.mit.edu/funding/travel-grant) and GWIP (http://web.mit.edu/physics/wphys/travel.html).

You can also apply to MISTI as a potential source for travel funds. Their site is: http://misti.mit.edu/

There is also typically a call every 6 months for proposals in the CTP to fund activities of graduate students, which could also enable you to be awarded additional travel funds.

Advisor relationship:

Besides your regular research meetings, every semester, meet with your research advisor to talk about your progress, what things you should improve, what conferences they might suggest for you to go to, etc. Note that beginning in AY 2019-20, all graduate students will be required to schedule such a meeting with the research advisor, and to document it for the Academic Programs Office.

Don't hesitate to ask for help in your research advising situation if you need it.

Fellowships:

Don't hesitate to apply for fellowships that you qualify for. That might reduce the time you spend teaching, and it looks good on your resume.

Examples of these fellowships are:

- NSF if you are a US citizen/permanent resident
- NSERC if you are a Canadian national
- American Australian fellowship association if you are an Australian national
- DOE computational sciences graduate fellowship
- Hertz fellowship
- Ford foundation fellowship for US citizens/permanent residents.
- DOE office of science graduate fellowship program.
- DOE National nuclear security administration.