How Do I Get to Graduate School?

CUWiP at Oregon State University, 2016

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(A significant amount of this material has been adopted from Pat Burchat:
https://physics.stanford.edu/sites/default/files/ApplyingtoGradSchool.pdf
https://physics.stanford.edu/sites/default/files/GradSchool.pdf)

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What to look for in a graduate program

Master's or PhD?

- **Option 1: PhD in Physics, Applied Physics, or Engineering**: This is the "standard" route that your undergraduate department is most likely preparing you for. You will be financially supported on a research assistantship (RA) or teaching assistantship (TA). You will have ~2 years for coursework and ~4-6 years of research. (Median PhD is 6 years).

- **Option 2: Academic Master's in Physics:** Full-time academic master's programs in physics are less common[1]. Typically master's degrees are conferred to students during their PhD studies. Students who do not complete the PhD may often leave the program with a master's (paid for! - not a bad deal!).

- **Option 3: Professional Master's in Physics (or Engineering):** These programs target to students who are already working in industry. The student may want to learn a new skill to change professions (for example medical imaging physics), or she may be supported by her company to learn a new skill for advancement within her company (e.g. Boeing/UW). Often evening classes which meet less frequently. Degrees take longer and are not as comprehensive as a daytime Master's program.

- **Option 4: Master's programs with aligned internships:** There are a few programs that offer industry internships with their Master's programs. They are unsupported but the internship is paid. One example is University of Oregon's Master's Industrial Internship Program (http://internship.uoregon.edu).

- **Option 5: Academic Master's programs in Engineering:** These are typically unsupported however may be useful for transitioning to industry.

- **Option 6: Medical Physics MS or PhD:** Medical physics is very well-paid. Some people go into the clinical side, others into instrumentation side. For more information, talk to CUWiP participant Miriam Lambert and visit : https://www.aapm.org/, http://www.campep.org/campeplstgrad.asp.

[1] 56 departments offer MS only and 199 offer PhD as the highest degree.
https://www.aip.org/sites/default/files/statistics/rosters/physrost14.pdf

Physics, Applied Physics, or Engineering

Many schools have "physics" being researched outside the physics department. When you look at a particular school, look for the research area(s) that interest you and see which departments have this research. Many engineering departments welcome physics undergraduates. Additionally, it is often possible to have a research advisor outside your department.

Department	Interest
Physics	Particle, Astrophysics, Cosmology, Biophysics Condensed Matter, Atomic-Molecular-Optical, Quantum Info, Physics Education, Plasma Physics, Nuclear Physics
Astronomy	Astronomy, Astrophysics
Applied Physics	Condensed Matter, Atomic-Molecular-Optical, Quantum Info, Biophysics
Materials Science or Chemistry	Condensed Matter, Materials Physics, Physical Chemistry
Electrical Eng	Quantum Info Experiment, Optical
Computer Sci	Quantum Info Theory
Bio/Bioengineering	Biophysics
Earth/atmospheric	Oceanography, atmospheric science, geophysics

Location, location, location

Odds are, you will spend 6 years of your life in graduate school. The location will matter to most of you. Things you may consider include

- Urban/suburban/rural environment
- Weather
- Proximity to friends/family
- Regional culture

Competitiveness of school (based on your transcript/letters/GRE)

- We recommend you apply to 6-10 schools. For example, 2-3 safe, 2-4 on-level, 2-3 reach schools.
- More in the next section on how to have the most competitive package.
- Stats on schools can be found at http://www.gradschoolshopper.com/ with more complete information (e.g. mean GPA) on the school's website.

Areas of ACTIVE physics/engineering research at the school

- Are there at least 2 research groups at the school whose research sounds interesting to you?
- Have these groups published in the last few years?

Funding level/type

- Most (all?) PhD programs in Physics in the US provide tuition and a stipend on which you can support yourself.
- Many programs start students with teaching assistantships however some programs have students that start with research assistantships.
- An internal or external fellowship can sometimes give you more choice of research area and adviser. Spend some time researching fellowship opportunities and apply when appropriate. For many fellowships, one must be a US citizen or permanent resident.
    - NSF Graduate Fellowship,
    - DOE Graduate Fellowships (Computational Science GF, NNSA Stewardship Science GF, High Energy Theory GF)
    - National Defense Science and Engineering Graduate Fellowship
    - Hertz Fellowship
    - Ford Foundation Predoctoral Fellowships for Minorities
    - American Association of University Women Fellowship
    - National Physical Science Consortium

Departmental/School Climate

- Female-friendly[2]
- Family-leave policy
- Professional development opportunities?
- Social events that might it a welcoming place?
- A good TA training program?
- Small vs. large? : Large institutions may offer more variety and sometimes more opportunity. Smaller ones offer a more personal experience. Often, faculty at smaller institutions are just as good, and publish just as much, but the fit to your interests may be more limited.
- Check the departmental websites for evidence of these things.

[2] http://www.aps.org/programs/women/female-friendly/

Exercise:

- Pick ~20 schools based on
    - http://www.gradschoolshopper.com/
    - recommendations by your professors (e.g. your research advisor, undergraduate advisor, favorite quantum professor)
    - other sources of information you may have (family, friends, research articles you have read)
- Go to each school's website and record in a spreadsheet
    - Metrics that indicate how competitive the school is (e.g. GPA, General GRE, Physics GRE, acceptance rate)
    - Metrics that indicate how you would rank the school (e.g. number of interesting research groups, size of program, location, climate)
- From this list, label each school as
    - out-of-my-league
    - reach
    - competitive
    - safe
    - would not go even if I got in
- Keep your top 4 schools in the reach, competitive, and safe categories. You can narrow these down further, add new schools between now and when you apply!

How to put together the your best application

There are four components to your package.

- Letters of Recommendation
- GPA
- General GRE and Physics GRE
- Statement of Purpose

An admissions committee will look at all 4 components for a competitive applicant. A competitive applicant may be any of the following

- Strong in all 4 components (of course!)
- Strong in Letters + GPA, OK in GRE, personal statement
- Strong in Letters + GRE, OK in GPA, personal statement (less competitive than above case, though)

We will discuss what it means to be "strong" more below.

Letters

Your 3 recommendation letters are arguably the most important part of your application. (I say arguable because some schools may have an order in which they look at applications that depends on GPA/GRE. If your application doesn't get looked at by the time they have filled the class, your strong letters may not help.) So how do you get the strongest letters?

Research Experience

The committee is looking for your potential as a research scientist, since this is what they will be training you to do. The easiest way for them to gauge your potential is to learn how you did as an undergraduate. Undergraduate research experiences also give you a taste of graduate school to see if you will like it. There are several ways to obtain undergraduate research experiences

- Work in a research laboratory in your school.
- Apply to REU programs, *especially* if there aren't research opportunities at your school. REU programs funded by NSF typically reserve spots for students who come from schools without research labs.
- If there aren't "real" research labs can you help maintain or develop undergraduate laboratories? See if a professor is interested in advising an independent study in which you tackle a subject through reading the literature.
- Industrial research internships or programs such as Engineers without Borders or autonomous car competitions, in which you develop a relationship with a mentor who can observe you do independent work or work in a team.

1 strong research experience is more valuable than 2 weak experiences. If you are happy working in a lab, don't feel pressured to change labs! The main exception is REU programs. It is understood that these are short 8-10 week programs and in general it is great if you can take part in one.

Interactions with other professors

The easiest letters for a professor to write are the ones in which they know the student. Make an effort to ask questions during, after, or before class. Attend your professor's office hours. You can ask questions about the homework (but be sure you have given it a good go first!) or about physical concepts. If there are discussion boards for your course, participate!

Other possible letter writers

Typically students have 1-2 research advisor letters and 2-1 letters from course professors. But sometimes it works in an application to have a letter from a boss (e.g. a job that required significant responsibility or technical skills), a professor who has seen you TA or knows of your reviews, the head of an organization in which you were a very active participant (e.g. the chair of your department who witnessed all the extra things you may have done for the department such as open-house night activities, reviving the SPS).

How to ask for letters

- **Ask letter-writers early.**
- Provide the following material at least three weeks in advance of the first deadline. Ask letter writers if they prefer electronic versions or hardcopies of materials (or both).
  - Unofficial transcript
  - CV or resume
  - Draft of personal statement
  - Offer to meet them
  - List of schools with due dates
- Keep lists of schools and materials VERY organized for letter. Do not give materials to letter writers in bits and pieces. Consider putting the lists and materials in a Google document to share.
- If you aren't organized enough to do the above, it is often OK. Still ask! The above is the "best practice".
- Remind your letter writer a few days before the due date if he/she has not submitted any letters yet.

Exercises:

- Prepare a resume/CV tailored
  - for applying to graduate school
  - for obtaining a research position at your school
- Seek a research position if you do not have one:
  - Find out if positions are available: e.g., surf your school's department website to learn what research exists. Look for labs that indicate they have undergraduate researchers. Do you know any undergraduates working in a lab? Do you know a course professor who could advise independent work?
  - Send an e-mail to the professors who look promising (include your CV and unofficial transcript) stating that you are interested in undergraduate research and inquire if positions are available. It is nice if your letter

indicates that you have attempted to look through what the professor does (e.g. from her website, her publications).
    - If the answer comes back negative, you can offer to work for credit, ask if you can attend the research "group meeting" for a quarter/semester, or ask if they know of professors who advise undergraduates.
- If you are quiet in class begin setting concrete goals
    - e.g. asking 1 question during or after class each week
    - attending office hours at least every other week

GPA

If you do not feel like you are doing as well as you should be in a class and you don't know how to improve your performance, set up an appointment with your professor to discuss this.

A high GPA is great. A rising GPA (e.g. strong junior/senior year) may also be fine. It may help to address the following, at least briefly, in your statement

- significant dip (e.g. a semester or year of poor performance)
- rocky start
- leave of absence

GPA may be less important than the GRE scores if you come from a school that is not well-known or is known for grade inflation. In these cases, a low GPA raises a red flag, while a high GPA may need to be corroborated by high GRE scores for a strong application

General GRE and Physics GRE

Some believe we should replace the GRE score with a metric that can better predict graduate school success
(see e.g. http://www.nature.com/naturejobs/2014/140612/pdf/nj7504-303a.pdf). This has begun to happen (e.g. Vanderbilt's astrophysics program does not require the physics GRE) but the reality is, this test is still very important (sigh). So let's make sure you do your best.

General GRE (nuts and bolts)

- General GRE has three parts: Verbal, Quantitative, Analytical.
- Do a practice exam so that you are familiar with the format. You can improve your score with practice and test-taking strategies.
- Low General GRE scores can raise "red flags" so do take the General GRE seriously.
- Some admissions committee members do not put much weight on analytical score unless it is anomalously low.
- Some schools list the range of GRE scores of accepted students on the AIP Grad School Shopper site as well as their own school websites.
- The **General GRE** is a computerized test. See the GRE web page to schedule an appointment: http://www.ets.org/gre

Subject (Physics) GRE (nuts and bolts)

- Test-taking strategy is important for the Subject GRE so plan to prepare.
- Prepare over the summer if you are taking the Subject GRE in Sept/Oct.
- Form study groups for Physics GRE preparation.
- Some schools list the range of GRE scores of accepted students on the AIP Grad School Shopper site as well as their own school websites.
- The **Subject GRE (Physics)** is a paper-based test and is given three times a year: September, October and April. See this link for a summary of the subject areas covered on the test: www.ets.org/gre/subject/about/content/physics
- Schedule an appointment at http://www.ets.org/gre. The registration deadline is more than a month in advance of the test and test centers do fill up, so register early!

Physics Subject GRE Study Resources

We include here useful information on preparing for the Physics GRE.

- Several practice tests are available on the web.
- The APS has prepared a webinar on "Acing the Physics GRE:Tips and Strategies." www.aps.org/careers/guidance/webinars/greprep.cfm
- A couple of MIT graduate students have put together a guide to studying for the Physics GRE: http://www.physicsgreprep.com/ Here is a description from their web site: "PhysicsGREPrep.com is an effort by two physics graduate students at MIT to remedy the astonishing lack of study materials for the Physics GRE. Frustrated by old, unrepresentative exams and a lack of comprehensive review material, we created a complete suite of study materials to help students earn the highest score possible." The book is available for ~$50 online.
- Here is a very useful Physics Subject GRE preparation web page put together by the Society of Physics Students at Ohio State University: http://www.physics.ohio-state.edu/undergrad/ugs_gre.php They have grouped problems by topic (Mechanics, E&M, Quantum, etc.) and arranged them into 18 "problem sets" to organize your studying. They have also written up solutions with tips on how to most efficiently arrive at the correct answer (dimensional analysis, symmetries, limiting cases, etc.). Of course, it is best not to look at the solutions until you have thoroughly analyzed the problems yourself. The web site also contains links to complete past exams and other resources.

GRE Exercises:

- Form a study group and study schedule with students in your area before summer starts
- At the start of summer, take one practice exam in an "exam environment," grade the exam, and use it to identify areas in which you most need review.
- Reserve the questions from one complete exam to do a final practice exam in an exam environment to work on strategies for when to skip a problem and move on to the next one.

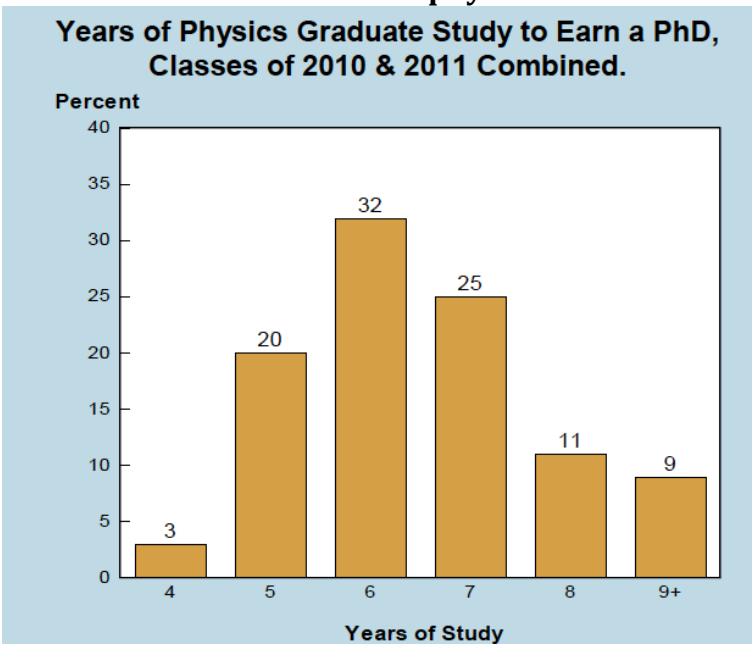
Statement of Purpose

- Schools often use the statement of purpose to look for "fit" with the opportunities in the department and balance in research areas across the incoming class. Include research areas of interest as well as the names of faculty who you may be interested in working with.
- It is okay to be specific or broad with your interests as long as you support your statement with evidence of your interest (--e.g. books or research papers you've read, research experience, coursework)
- It is okay to have more than one area of interest. You are being realistic!
- Be specific about achievements and goals, avoid "fluff" in your statement.
- In discussing your research experience, emphasize the big picture (scientific goals) as well as articulate your specific contribution toward this scientific goal. Include what you have learned about your interests.
- You may briefly address an anomaly in you application or unusual circumstances if you think it would strengthen your application overall. A second opinion for your particular situation is useful in this case. Some applications allow a personal statement in addition to the statement of purpose. If this is the case, the appropriate place for this discussion is in your personal statement. If you have a close letter writer, it may be appropriate for him/her to mention the circumstance. Life happens to everyone.

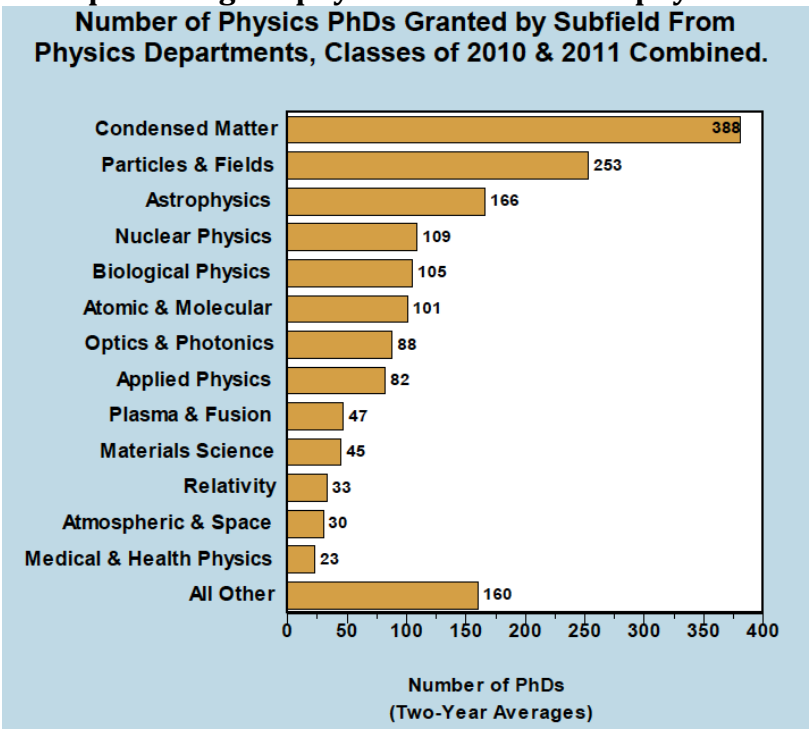
Physics statistics

Many answers to questions related to going to graduate school after a physics undergraduate degree can be found at the AIP statistical research center site. https://www.aip.org/statistics

What is the median time to a physics PhD?



What percentage of physics PhDs are in biophysics?



What percentage of physics PhDs are female?

Demographic profile of Physics PhDs, Classes of 2010, 2011 & 2012 Combined.

Sex	Male	81%
	Female	19%
Citizenship	U.S.	51%
	Non-U.S.	49%
Average Age		30.5

http://www.aip.org/statistics

What percentage of physics faculty are female?

Percentage of Physics Faculty Members Who Are Women

	Year			
	1998	**2002**	**2006**	**2010**
by Academic Rank	(%)	(%)	(%)	(%)
Full Professor	3	5	6	8
Associate Professor	10	11	14	15
Assistant Professor	17	16	17	22
Instructor / Adjunct	*	16	19	21
Other ranks	13	15	12	18
by Highest Degree Offered by Department	(%)	(%)	(%)	(%)
PhD	6	7	10	12
Master's	9	13	14	15
Bachelor's	11	14	15	17
OVERALL	**8**	**10**	**12**	**14**