Physics in College

A talk for my beloved Andover Physics Club

Jason Huang

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Overview

Why do you want to do physics?

- Every one will ask it. Too big of a question! Much better to ask

  Why do you want to do [BRANCH NAME] physics?

- Different branches of physics study different things and require different skill sets.
- Traditional division between "theoretical" and "experimental" + subfield (e.g. "astro", "condensed matter", "optics", "high energy").
- A comprehensive list of categories in research: https://arxiv.org/category_taxonomy

But how do you figure out what kind of physics you want to do? Go to college!

Physics in College

I will give an overview for the following two topics:

- Course work
- Research
- Career aspects

College Physics Coursework

Usually physics classes are organized like this:

- Four major subfields: Classical mechanics, E&M, Statistical mechanics, Quantum mechanics
- Three tiers of difficulty: intro, intermediate, grad
- Many other classes on specialized topics offered at intermediate and grad levels

Of course, don't forget the math requirements...

- Generally required: calculus, multivariable calculus, linear algebra
- Highly useful: differential equations (ordinary and partial), complex analysis, probability & statistics
- Some math classes may be useful for certain subfields.

An Example of Coursework Organization

Topic: E&M

Intro-level

A course on the level of AP Physics C. for students who have not taken it in high school;

Intermediate level

Course 1: Rigorous treatment of Maxwell's Equations in differential form (Textbook: Purcell);
Course 2: Electrodynamics, electromagnetic waves, radiation (Textbook: Griffiths);

Grad-level

A course on even more buffed up electrodynamics, relativity (Textbook: Jackson);

Another Example of Coursework Organization

Topic: Quantum

Intro-level

A course on modern physics and its development (similar to the one at Andover), all the way up to Schrödinger;

Intermediate level

"Quantum A & B"–a year-long sequence ranging from the algebraic foundation to perturbation methods (Textbook: Griffiths)

Grad-level

Course 1: graduate-level quantum, served as a review for incoming grad students (Textbook: Sakurai);
Course 2+: quantum field theory (Textbook: Peskin & Schroeder)

My Two Cents on Courses...

1. Andover has prepped you well for intro-level classes. If you can, aim for intermediate classes when you enter.
2. Do not ever overextend yourself! If you feel that your understanding of a topic is not sufficient, it is good to take a class to revisit the topic. Don't be afraid of revisiting topics. Skim the associated textbooks to know if you are prepped for a class.
3. If you wish to go theoretical, you should take high-level math classes (functional analysis, abstract algebra, etc.).
   If you wish to go experimental, you should consider computer science and engineering classes (microelectronics, software, etc.).
4. Do take introductory programming classes! They are highly useful for physics research, but hardly any department requires them for the degree.
5. Addendum: CS is a must and please take a lot of it for your own benefit!

Doing Research

Doing research is the best way to figure out your favorite branch of physics.
In the States, the general expectation is that a physics student would do some research outside of coursework through their undergraduate time.
Hierarchy of a research group / "lab":

1. Principal investigator ("PI"): usually a professor; receives funding from the government, the university, and other sources; delegates work, manages the group, and provides high-level ideas;
2. Post-docs, who are minions of the PI; oversees the group and makes significant contribution to projects;
3. Doctoral and Master students, who are minions of the PI: works on their own significant projects for the degree;
4. Undergrads, who are ...

Doing Research

To get into research:

- Different schools usually have mechanisms that provide a fund for undergrads to do research with professors. Usually an internal application.
- Alternatively, you can (and sometimes should) reach out to professors that are doing funny things that you like. Professors love when people reach out to them so they can talk about their little things, **provided** that they are not too busy.
- The same rules apply to professors outside of your school, but they have no obligation to take you into their group.

For undergraduate research in college:

- You are not expected to take on great projects during your time. But if you impress your professor enough, they will let you become more involved in the lab and take on bigger things.
- You are not expected to remain with a certain lab group for ever. Professors understand that you will need to try out different branches of physics.
- You will be paid minimally.

How Much Research should I do?

- If you wish to go to graduate school, you should do as much as possible;
- If you wish to work in industry after graduation, you should do research that is related to the subfield you are interested in.

But, Jason, how do I know whether I should go into grad school or industry?

- Do some research and find out! The process of research in physics is much different than taking physics courses.

Activities and Career

When you are in college, you should think about what you want to do after. Find your passion early so you could devote enough time and efforts towards your goal.
Generally, two major outcomes for physics undergraduates: academia and industry.

- Academia: you keep doing physics research.
  - US undergraduates usually apply for a PhD program (five to six years) after undergrad. It is also common to do one year of research afterwards to strengthen one's profile.
- Industry: you apply what you learned into real life.
  - Engineering, tech, finance, etc.

Both require you to **specialize**—to be good at one thing that you do, so they will know that you're a good fit. Fortunately, you have about three years to do this...

Preparing for Career

- To get into PhD in Physics:
  1. Three letters of recommendation (hint: three lab groups)
  2. Research statement (delineating one's research background and goals in PhD)
  3. Transcript, grad classes preferred
  4. Personal statement optional
- To get into industry:
  1. Follow the recruitment schedule of the sector you wish to get in
  2. Intern at related positions
  3. Take related classes and do personal projects

Plan your term time and summers accordingly!

Question Time!

Ask me anything...

Thank you!