

Undergraduate Physics Research Guide

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Introduction

During the course of earning a degree in physics, students will learn many valuable skills in the classroom.

Students who only learn from the classroom, however, cheat themselves out of the valuable experience of undergraduate research.

Some students find it difficult to identify research positions or do not want to participate in research. The purpose of this document is to convince undergraduate students to become involved in research and to give students seeking a job the skills they need to find a position.

Motivation

A very reasonable question to ask is why a student should become involved in research. Students are already busy with difficult classes and the daily toils of college so why should they put a job on top of that? The answer is that experience gained in undergraduate research is indispensable.

By doing research, students gain experience in a broad range of categories that they would not be exposed to in the normal course of study as a student. If a student plans on going to graduate school, they will end up doing research in some field. This means that having some amount of research experience will be valuable in

determining the type of research the student will do. Even if a student does not find their ideal research position, they will learn what they like and dislike about a particular job and can use this information to make future career decisions.

A research position will also give a professor the opportunity to become familiar with the work habits of a student. Professors who know students well can often write better letters of recommendation for students seeking jobs or graduate admissions. Possibly the best reason that a student should be involved in research is that it gives them the opportunity to use their knowledge of physics. Students who do research often are more interested in their courses, as they have seen firsthand how the effects they student in the classroom exist in the laboratory.

How to Get a Research Position

So you want a job but you have no idea how to get one. The Physics Research Building is very large and there has to be a more efficient way of getting an in than going door to door. Some students effortlessly get jobs while others seem to struggle for weeks to no avail. Here are a few things a student can do to dramatically increase their chances of finding a position.

Step 1: Determine Your Interests

There are several fields of study from which a student can choose. Each field offers unique challenges and will have their own charms. Determine one or two fields that interest you and identify the things in this field you would like to study. The best way to look into this is to go to the physics department website (physics.osu.edu/ug-research) and look at the research efforts that are going on.

Another way to learn about the different fields of study is to attend Society of Physics Students (SPS) meetings. SPS meetings will give you a fairly detailed explanation of what is happening in a specific research effort. Additionally, this will put you in the same room as the professor doing research and will allow you to interact with them at the end of the meeting.

The third way of identifying a field of interest in to take Physics 2095. If you are still unclear of some aspects of specific fields, your undergraduate physics advisor should be able to either answer your questions or point you in the direction of someone who can.

Step 2: Continue to Narrow Down Your Search

After you have found a specific area of physics that interests you, the search continues by finding interesting efforts in that field. I would suggest finding two or three professors in two different fields (totaling four to six professors) who are doing research that interests you.

The same methods used in step one should be used to narrow this search. Another good technique for finding professors who are doing research in your area of interest is to ask them what they do. If they are enthusiastic about their experience, it is likely you will have a similar experience with the same professor should you get a position with them.

Step 3: Research your Research

Now that you have identified possible candidates to apply to, it is time to roll up your sleeves and learn a thing or two about their research effort. Most, if not all, professors here maintain webpages so go to them and read about the type of work they do. You may not understand everything that appears in their papers but if you make an attempt to learn a few buzzwords and try to acquire a general sense of the goals of their research efforts, you dramatically increase your attractiveness as a researcher.

Students who display enthusiasm for the field show an ability to work independently and show they have the basic skills necessary to do research. The more you are able to find out about a particular research effort, the harder it will be for a professor to deny you a position.

Step 4: Contacting Faculty

After you've identified specific research efforts that interest you, and after you have learned the basics of the field you wish to pursue, it is time for you to inquire about a position. You can find the contact information for physics faculty on the directory located on the physics website. It's recommended that you email each professor individually, explain who you are, your qualifications (GPA, major, classes you've taken, etc.) and the specific reasons why you're interested in their research (this is where your knowledge of their research efforts come in to play). Then ask if they are available to discuss their research with you. Keep in mind that the professor may request an up-to-date resume so make sure you have one ready just in case.

If you have experience with programming, data analysis, statistics, or electronics, be sure to mention these skills in your email to the professor. It's okay if you do not have these experiences. In fact, few undergraduates have experience prior to seeking an undergraduate research position. Faculty have reported that the number one factor they are looking for in an undergraduate researcher is enthusiasm for their project.

At this point your hard work should show how intelligent and independent you are. If you made an honest effort to learn about the research effort you are asking about, you have no reason to be nervous. Also keep in mind that the overwhelming majority of professors are very friendly so stay calm and let your hard work show.

Step 5: The Day of the Meeting

One the day of the meeting the first thing to consider is your appearance. While the physics community tends to be more informal than the business world, it is important to remember you are applying for a job. A suit would certainly be over dressing and t-shirt and torn jeans would be under dressed. Business casual is likely the best route. Dressing appropriately will not get you the job but under dressing could keep you from a position you deserve. In addition to being dressed appropriately, students should be well rested and well groomed.

Step 6: Be Patient

It is easy to become discouraged if you are not immediately successful. Do not get down if your top choices have no available positions. There are many factors that go in to getting a position, many of which are out of your hands. Many times professors already have a number of students working for them and by taking on too many students, a professor will overburden himself or herself to the point they cannot effectively help any student.

If a professor cannot offer you a position because he or she does not have adequate funds to pay you, consider volunteering until additional funds become available. Additionally, keep expanding your selling points whenever possible. As you take additional technical courses, be sure to include those in your updated resume or list of skills. Also try to find summer research positions such as the Research Experience for Undergraduates (REU) program funded by the National Sciences Foundation.

Frequently Asked Questions

Q: How can I get involved in research?

A: Pages 2-4 of this document should provide you with the information you need but please feel free to contact your physics advisor or talk to one of your physics professors if you have any questions or would like additional help.

Q: Which research topics are available?

A: Great question! The Department of Physics faculty do research in a wide range of fields. The webpage physics.osu.edu/ug-research provides an overview of the research efforts in the department and can give you an idea of what your research options are. If you are unsure of which field would be the best fit for you, please speak with a physics advisor who can help you narrow things down base on your interests and skills.

Q: When is the best time to get involved in undergraduate research?

A: We encourage anyone who is interested in undergraduate research to try to be involved by the end of their sophomore year. You can certainly still get involved during junior or senior year but doing so won't allow you as much time to learn and contribute to the project. Some students get involved as early as freshman year but you should not feel pressured to do that if you are not ready to add research to your plate at that time.

Once a student is ready to get involved in research, they can start contacting professors any time during autumn or spring semesters. Summer might not be the best time to ask about research as faculty might be traveling or on vacation. If you are interested in getting involved in research during the summer, we recommend that you start looking for a position in February or early March so that you can apply to summer research scholarships before those deadlines pass.

Q: Which qualifications are necessary?

A: Physics faculty want an undergraduate researcher who is enthusiastic about their project. Research is challenging and rewarding but it can also be slow, tedious, and frustrating so if you are not interested in the work, you might not be motivated enough to make a lot of progress. This is why it is important that you have an understanding of the professor's research before asking to get involved. And it's also why you should express enthusiasm for the professor's research during your initial contact with him or her.

Other skills such as previous experience with programming or electronics or credit for specific math or physics courses are not always required but can be helpful. The research group you join will help you learn any skill or concept that you need to be an effective researcher, so do not feel like you need to come in to the group already knowing how to do everything because that is not the expectation.

Q: If I become involved, what is expected of me?

A: The answer to this question will depend on the group you join so you should plan to ask this question when you meet with a professor to discuss possibly joining his or her research group. In general, expectations of undergraduate researchers include, but are not limited to,

- Follow the rules of the lab. Equipment can be very expensive and dangerous so it is important you know and follow the proper protocols.
- Follow directions and guidance provided by those more experienced than you. This will include the professor you are working for but it might also include post-docs, graduate students, and older undergraduate students.
- Seek help when needed but also learn when you should try to solve a problem on your own. This is a skill that takes time to build and you will have time to develop this skill during the course of your undergraduate career.
- Be reliable. Show up when you say you are going to show up.
- Work hard.
- Be honest. If you need to reduce the number of hours you spend in the lab each week or if you've decided that you want to try a different area of research, make sure to convey this to your research professor. He or she will likely be understanding of your situation.

Q: How useful is the undergraduate research experience?

A: Many undergraduates have heard that undergraduate research experience is necessary for those who want to go to graduate school. This is true because a graduate admissions committee will need proof that you can be a successful researcher in order to admit you to a program that will require you to perform independent research.

But research is recommended to everyone, not just those who plan to pursue a physics Ph.D. The reason is because the skills you learn and the experiences and connections you make during your time as an undergraduate researcher are important. Students have reported that they've gained the following skills during their time in the lab:

- LabVIEW programming
- Project Management
- Autodesk Inventor
- Data Analysis
- Designing Machining
- Computer Aided Design (CAD)
- Data Acquisition
- Solidworks
- Public Speaking
- C++ Programming

- Mathematica Programming
- Chemical Etching
- Python Programming
- Manufacturing and Design Experience
- Projection Lithography
- Independent Problem Solving
- Analytical Methodology
- Proper use of Laboratory Equipment
- Experimental Electronics Skills
- Experimental Design
- Optical Engineering
- Photolithography
- Microscopy
- Java Programming
- Spectroscopy
- Cleanroom Techniques
- And many more

The above skills are very marketable. If you combine the skills and knowledge you gained in the classroom with those you gained in the lab, you will have a strong resume.

Additionally, graduate students, post-doctoral researchers, and faculty who you get to know by doing research can be instrumental in helping you obtain your career goals. They may connect you to an acquaintance in a field you are interested in or they may offer to be a professional reference when you are job hunting.

Aside from being useful for job hunting and graduate school, undergraduate research in physics will help you learn more physics!

Q: How easy is it to integrate research into your weekly schedule?

A: Just like everything else, it takes practice. You might consider starting slow (~5 hours a week) during the school year and adding more hours if you feel like you can handle it.

It's also important that you plan a weekly schedule and stick with it. For example, You might decide to do 2.5 hours of research on Tuesday and Thursday mornings before your classes start. Or maybe you do 1 hour of research at 4pm every day after your classes have ended for the day. Coming in to the lab on a regular basis is helpful for your research group as well because then they will know when to expect you.

Keep in mind that most university research labs are active during business hours (Monday-Friday 8am-5pm) so when you are getting started, you will likely need to

be in the lab during those times so you can get help from your group. When you become a more independent researcher, it will become easier to work during different hours of the week.

Q: In regards to the process of getting involved, I am still unclear about how best to have a conversation with someone conducting their research about the possibility of joining them. I will have only had minimal experience with their topic (possibly just reading some of their papers), while they will have spent years understanding the topic. I do not want to appear as if I have no knowledge of the subject, but am afraid that is inevitable when in conversation with someone who knows a lot about it.

A: Faculty are familiar with the physics knowledge that undergraduate physics and engineering physics majors have. They were once an undergraduate student as well and they will not have inappropriate expectations for you. Faculty want undergraduate students to get involved in their research because they want to teach you what they know and they want you to learn as much as possible about that particular research topic. If you already knew everything, there would be no point in joining the group.

Don't feel badly about your lack of knowledge. Just tell the professor what you do know (even if it is very limited – which is to be expected) and make sure you are enthusiastic about learning. That's really all you need!

Q: For students who have done research, how did the initial process of entering into the lab environment go? I am curious to know how the transition was from never doing research to finding yourself in a lab for professional work.

A: It is like any new job. At first, you might feel like you have no idea what you are doing but that feeling will gradually go away as you learn more skills, understand the research better, and become more acclimated to the lab.

Undergraduates should not expect their hands to be held through every task. One of the purposes of undergraduate research is for students to learn how to work independently and to solve problems for themselves. But members of your group will help you learning anything that you need to become an effective researcher (physics concepts, programming language, equipment, electronics, etc.). It is a balancing act between working independently but also relying on your group members to help you when you need it. This is a useful skill to have for your future career.

Q: Which physics courses are generally required in order to be considered for a research position?

A: It depends on the type of research you want to get involved in. Most groups do not require students to have completed anything beyond Physics 1250 while others might ask that you complete certain courses before getting involved or shortly after joining the group. If you are interested in working for a certain professor, you can contact him or her, let them know which physics courses you have already

completed, and ask him or her if you meet the criteria to join the group or if there are other courses you will need to complete first.

Q: I have questions about getting involved in undergraduate research. Who should I talk to?

A: Ms. Lindsey Thaler (thaler.21@osu.edu) and David Zach (zach.11@osu.edu) can recommend certain groups based on your interests and skills. They can also answer questions about the process of getting involved and research and help you understand what to expect.

Dr. Tom Humanic (humanic.1@osu.edu) is helpful if you have a specific type of research project in mind and would like to know if anyone in OSU Physics is working on something similar. He can also provide more specific information about physics research than what is posted on the website.

Your physics professors are a good resource and you might take the time to ask your professor about their research project so you can learn more about the options available in the department.

Physics 2095 and SPS meetings are also a great resources to help you meet new faculty and hear about their research projects.

The [OSU Undergraduate Research Office](#) can also be helpful in connecting students to undergraduate research, especially if you are interested in research outside of your major. They can also help you find research funding and research internships off campus.

Q: There are several areas of research within physics. How do I choose which branch of physics I should involved in?

A: See the answer to the above question.

Q: What is the time commitment required for undergraduate research? Are undergraduate researchers expected to do research during summer?

A: You should discuss expectations with the faculty member before you decide to join their research group. Most faculty will not require you to continue research over the summer but they might recommend it. The hours you will need to work each week depends on the group (equipment you need to use might only be available during certain hours, etc.) but the hours you can work are generally flexible. Keep in mind that most research is done during regular business hours (Monday-Friday 8am-5pm) so you will likely need to work within those limits until you are able to work independently.

Q: Are there any skills that are important/helpful to have (besides coding skills, outside involvement, etc.) when applying for a research position?

A: Most research positions in the Department of Physics do not require technical

skills or previous. But you will need to be reliable, enthusiastic, and easy to work with. This is true for all jobs. Some research positions might require you to have previous programming language so you might take some time to teach yourself the basics of Python or C++ if you haven't already.

Q: What is Physics 4998 and Physics 4998H? They are listed as Undergraduate Research Courses.

A: Students who are involved in undergraduate research are able, but not required, to enroll in Physics 4998 (non-honors students) or 4998H (honors students). Some students enroll in the class because they want undergraduate research credit to appear on their transcript. Others might enroll in the class in order to be considered a full-time student during a certain semester.

Please note that you must already be involved in research before enrolling in Physics 4998 or 4998H.

If you are interested in taking Physics 4998 or 4998H, please follow the enrollment directions outlined in the "Research for Credit" section on the [physics undergraduate research webpage](#).

Q: What is Physics 4999 and 4999H? They are listed as Thesis Undergraduate Research courses.

A: Physics 4999 (non-honors students) and 4999H (honors students) are taken by those who are pursuing the "graduation with research distinction" option. Students who are working toward a thesis will enroll in Physics 4999 during their senior year when they are writing their thesis. Additional information about Physics 4999 and the undergraduate research thesis can be found in the "Graduation with Research Distinction" section of the [physics undergraduate research webpage](#).

Advice from Students to Students

I currently work in a research lab. I wish I knew before starting research how slow it goes. I thought I knew how prolonged each process would be but it is definitely slower than I expected.

I wish I knew before/early on that it is okay to feel like you're playing catch up all the time. This is normal, especially if your field is particularly technical. The key is to keep at it and dedicate just a little time each week to learn a little bit more and figure out what useful questions to ask your advisor.

I wish I knew to start looking at a large variety of options for research instead of narrowing myself to a field or two that I thought would be interesting. I ended up wasting a lot of time by emailing professors for already saturated research positions.

It takes some time before you can really start contributing to the group. I started doing research during my freshman year, and I had to spend a good deal of time reading papers and learning about the software before I could actually start doing anything. My group then gave me some simple tasks to work on while I was getting myself situated, but I felt guilty that I didn't have ideas of my own to bring to the table! I wish I would have realized that it's okay to not know what you're doing at first, because the whole point of doing research is to learn how to ask the right questions and to learn to think like a scientist.

My advice would be find a lab that is "undergrad-friendly". In other words, a lab where you can be hands on right away and the PI enjoys having undergrads in his lab.

I think a very good strategy (if you have some idea of what interests you) is to ask your professors if any of their colleagues do that sort of thing and are interested in taking on undergrads. I think this works a lot better than trying to find someone to work with on your own.

Really try to understand the main question/questions a research group is asking about nature. Then ask yourself if that is a question you have too, or if you have related questions and think you would enjoy working on problems with that group. Bottom line is undergrad research is about UNDERGRADS, and them only. This is your time, make sure you are doing what you want with it and that your research experience is about YOUR PERSONAL DEVELOPMENT as a student and budding scientist. If you can, try to get a feel for whether or not the professor/grad student thinks this (even a teeny tiny little bit) too. You must demand to be paid attention to and "taken care of" intellectually (people in the group willing to help you

understand things in the lab, sit down and help you configure software/debug code, write up and explain some equations on the board). Without this type of relationship, you will struggle to contribute to the group and will not grow as a researcher and teamworker.

Use the resources around you. There are plenty of great people to talk to (like Prof. Perry) that can advise you about what Professors might be working on something that would interest you. Have an idea of what you want and they can help you get there.

I learned everything I needed about the research after getting started, so no need to worry about the lack of knowledge. For those looking for a useful class, linear algebra has helped me a lot.

I did my best to search for a professor whose research I'm really interested in by looking at personal websites and published papers, and ask only him for the research so that I could not only get to know the professor enough but also show enthusiasm. I advise people not to send lots of short emails to professors, but search a professor who'll fit your interest carefully and ask that person for research with sincerity.

Don't give up or get discouraged. I emailed and talked to many professors before finding a stable research position. This search can be hard at times. Also, showing a little backbone at times is beneficial in the research search.

Go to the research talks that SPS/Sigma Pi Sigma organize on Tuesday nights! This is a great way to learn about the research being done in the department. Another thing you can do is look through the faculty list on the physics website and write down names of people who are doing interesting research. Then, send out emails to the people who caught your interest and see what happens! The emails should be specific enough that the professor knows you care, but don't feel the need to write an essay in the email. If they respond, great! If not, send them a follow up email a week later, or try somebody else. Don't take it personally if it takes a while to find someone who has space for you! If you want to do research, it will happen if you keep trying.

For undergrads looking to get into research, including incoming freshmen, I strongly suggest emailing professors early on. I myself emailed professors during the summer before I was enrolled at OSU asking if there were any undergrad positions in their research group, and if it was possible to set up a meeting anytime during the summer. On top of that, I would think it goes without saying that you should know what the professor's research subject is and have a genuine interest in it.