

the SPS Observer

Volume LX, Issue 2

FALL 2026

THE GRAD SCHOOL ISSUE

- + Applying to Grad School in a Time of Uncertainty
- + Building Uncertainty with Confidence
- + Advice from Those Who've Been There
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The **SPS Observer** (ISSN 2160-1305) is the magazine of the Society of Physics Students, published quarterly by the American Institute of Physics, printed in the USA. **POSTMASTER:** Send address changes to The SPS Observer, One Physics Ellipse, College Park, MD 20740-3841.



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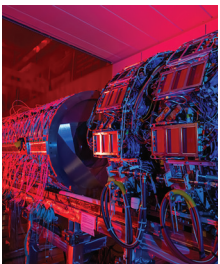
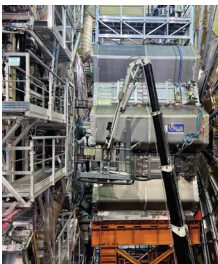
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ON THE COVER
University of Pittsburgh SPS students gather on campus. Photo courtesy of the chapter's 2025–26 SPS chapter report.



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ACA: The Structural Science Society
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AVS: Science and Technology of Materials, Interfaces, and Processing
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Other Member Organizations:

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As a 501(c)(3) non-profit, AIP is a federation that advances the success of our Member Societies and an institute that engages in research and analysis to empower positive change in the physical sciences. The mission of AIP (American Institute of Physics) is to advance, promote, and serve the physical sciences for the benefit of humanity.

SPS: A Partner on Your Professional Journey

by Ronald Kumon, Medical Physics Graduate Certificate Student, Wayne State University, and SPS President

As someone who has spent much of my career working with undergraduate physics and astronomy students, I understand how exciting, and sometimes overwhelming, it can feel to think about the next steps in your journey. My own experiences pursuing advanced study, combined with years of service and engagement through SPS, have reinforced how important mentorship, community, and access to resources can be during this stage of life. One of the things I value most about SPS is the opportunity to support students as they explore their futures, connect with professionals and peers, and discover the many paths available within physics and astronomy.

In this special graduate school edition of the *SPS Observer*, we share insights, resources, and encouragement to help you be more informed and confident about whatever comes next. With that in mind, I want to highlight two of SPS's objectives (see page 6 for the full list) that, as president, I work to advance:

-  **Stimulate interest in advance study and research in physics and astronomy.**
-  **Provide liaison between students and the member societies of the American Institute of Physics.**

Stimulate interest in advance study and research in physics and astronomy.

Do you want to be a professor or researcher at a government or industrial lab? These positions usually require advanced study and research experience in physics, astronomy, or a related field that

can only be obtained by completing a PhD graduate program.

I majored in physics and math as an undergraduate. I liked physics the best and thought that I might want to be a physics professor someday, so I did all the things that were recommended at the time: gained research experience through two Research Experience for Undergraduate (REU) programs, took the General and Physics Graduate Record Examinations (GREs), worked to revive our SPS chapter to build my leadership skills, and cultivated relationships with professors. In the end, I applied to eight PhD programs, was accepted to four, and chose one which had several areas of research that I was interested in.

However, that was several decades ago. To get a sense of what students should do in the current environment, I checked in with two first-year graduate students and former SPS National Council members: Leo Illing, now studying physics at the University of Colorado at Boulder, and Jacob Callebs, now studying astrophysics at the University of Oklahoma.

Leo advises undergraduates to look at ads for jobs that they could see themselves holding. If those jobs require a PhD, he said, then going to graduate school may be a good move. However, he noted that the first year of grad school is mostly coursework, and it's important not to arrive burned out. He knows several students who delayed grad school, opting for another STEM experience first, and said this path didn't put them at a disadvantage.

Jacob recommended that students planning to apply to graduate school get on top of their applications early, at least the summer before they are due. He also recommended using a spreadsheet to



ABOVE: Ronald Kumon.

track programs and advisors of interest, due dates, fees, and other important notes. Talking to your research advisor or other professors in your current program is a good way to get recommendations for advisors elsewhere, he said. He wants students to know that getting into grad school is a competitive process, so applying to multiple programs is advisable, and that some programs will waive application fees on request.

Both Jacob and Leo noted that the GREs are no longer required by all programs, so you may not need to take them (check with the programs you're interested in to be sure!). Leo also strongly recommended reaching out to specific professors or groups that you are interested in working with before applying. And after receiving an offer, Jacob suggested reaching out to current graduate students to gain insights about the transition into that program.

Where can SPS fit in? Leo said that his SPS activities gave him unique experiences to talk about on his applications. He also

valued being part of the SPS community of students and PhD physicists and the sense of belonging it provided, in addition to opportunities to develop networking, communication, and leadership skills. Jacob highlighted that he learned about graduate school resources via the SPS and AIP [GradSchoolShopper.com](https://www.gradschoolshopper.com) website (see page 30).

If you're thinking about graduate school but don't know anyone who does what you want to do, I encourage you to visit the SPS/Sigma Pi Sigma Alumni Engagement Program (students.aip.org/find-a-mentor). You can connect to alumni who have been through grad school and may be able to advise you on your journey.

Provide liaison between students and the member societies of the American Institute of Physics.

SPS is part of the American Institute of Physics (AIP), a federation of member organizations in the physical sciences (aip.org/federation). As

a result, SPS members receive membership in two of ten other professional societies as part of their annual dues.

Why is it important to be part of a professional society? These societies sponsor conferences, publish journals, maintain professional standards, and provide networking and education opportunities. If you become a PhD physicist or astronomer, you will likely be part of several of these during your career. Joining now can give you a peek into current research in your areas of interest, who is doing that research, and hot topics in the field. This background information can be invaluable as you decide whether and where to apply for graduate school and articulate how you can contribute to a field.

Whether you decide to go to graduate school or not, I hope this issue can help you move into the next stage of your career. Please reach out to me or the SPS National Office if you have questions or need more information about SPS resources. We are here for you! //



ABOVE: The students on the 2025–26 SPS Council at the Physics and Astronomy Congress. Photo by SPS.

THE SPS COUNCIL

The SPS National Council is the governing body for the Society of Physics Students and Sigma Pi Sigma, the physics honor society. Student and faculty representatives are elected from each of the 18 SPS zones every year. To learn more, visit students.aip.org/leadership/national-council.

THE SPS OBJECTIVES, AS DESCRIBED IN ITS CONSTITUTION:

- 1. Encourage and assist students interested in physics and astronomy to develop the knowledge, competence, enthusiasm, and social responsibility that are essential to the advancement of physics and astronomy;
- 2. Stimulate interest in advance study and research in physics and astronomy;
- 3. Develop collegiality among physics and astronomy students and faculty members;
- 4. Promote public interest in physics and astronomy;
- 5. Provide liaison between students and the member societies of the American Institute of Physics; and
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Inside a European Graduate Program

by Austin Olson, PhD Candidate and Researcher, University of Siegen, Germany

My first push toward studying physics came from a high school teacher with an infectious passion and an ability to make the material accessible and interesting. I developed a more extreme interest during an undergrad course on modern experiments with a large focus on particle physics. I worked with two dark matter experiments, LUX-ZEPLIN and Darkside-50, and greatly enjoyed both, particularly the complexities of the detectors' design impurities and background elimination, and I really loved being a part of large collaborations. My professors were enthusiastic and kind, and they did a great job preparing me for exactly the type of work I'd be doing in physics.

One of my classes as an undergrad at Augustana University was an independent study of classical mechanics, in this case using computing programs to define, plot, and predict systems of motion or dynamic change. It was enjoyable and challenging in a satisfying way, like a puzzle. Along with classes on the philosophy of religion and history of mathematics, the course made me appreciate the material world and the societal systems that

would allow me the privilege of working in physics. Altogether they convinced me that it would be a life-fulfilling career, so I decided to pursue a PhD.

I found, however, that my graduate school wasn't a great fit. After I met the master's degree requirements, I decided it would be a smart move for my career and mental health to leave the program early and search in Europe, where I hoped to move anyway. In Europe it's common to start PhD programs after earning a masters, and there the research supervisors hire graduate students directly for projects rather than the physics department handling admissions. The stability of this system was important to me after having three research advisors, all at different times, during my masters. Also, most of my experience was in dark matter WIMP searches and rare-signal high-energy physics

■ **BELOW:** The city of Siegen, Germany.



searches, and Europe had many such experiments and projects that appealed to me.

The University of Siegen in Germany has a really wonderful physics department. My advisor, Professor Markus Cristinziani, is down to earth, and the other professors and post-docs are always supportive and helpful. We're working on a Higgs to charm-anti-charm search for ATLAS, a detector at CERN's Large Hadron Collider (LHC) in Switzerland. Right now, I'm improving machine learning-based flavor identification tools. There are multiple layers of supervisors for various projects so I can always find someone to help with whatever I'm doing.

The department is small and interactive, and everyone has lunch together. The students have an official group excursion in the summer and a lively Christmas party in the winter. The department and professors feel overwhelmingly well connected to other schools and programs, so I'm often immersed in an environment that's full of passionate career physicists.

One huge benefit: Traveling to other schools, conferences, and CERN is easier with everything so close and travel costs more reasonable. Seeing different cities and countries while also meeting people from all over Europe makes the PhD experience much more fulfilling. And I've found the more focused, narrow research groups of European graduate programs make for a rewarding day-to-day experience. Here, I feel more strongly that my research is contributing significantly to the field of physics.

On the other hand, a benefit in the US was the very open atmosphere—experimentalists, theorists, particle physicists, and condensed matter physicists all interacted every day. In German PhD programs, each of these groups is an isolated unit.

For me, the biggest drawback to an international program has been loneliness. When you're in a foreign country long term and trying to socialize, it takes time to fully understand that you are the foreigner, the odd one out. It can be challenging to befriend locals, who've often never left their region for long periods of time. And there are certain cultural aspects, and even the vibe of my masters physics department, that I miss greatly.

After my PhD, I plan to stay in Europe, either in Germany or Sweden. I hope to continue working in physics, especially with CERN, but otherwise I'll utilize my experience with large-dataset manipulation and machine learning to get a private industry job in energy technologies or computing.

THINKING ABOUT GOING INTERNATIONAL?

The application process takes some perseverance. The typical European school asks for letters of recommendation, an essay on your interest in the field, an explanation of why you think you'd be useful to them (and a good fit), and finally an interview where they ask standard job interview questions and sometimes test your physics knowledge. Another difference from US programs is that in Europe (and, presumably, other parts of the world) you're expected to already have a masters degree and some research experience. Schools want to gauge your usefulness, your potential

to remain in the program despite the occasional months of pressure, and your personality.

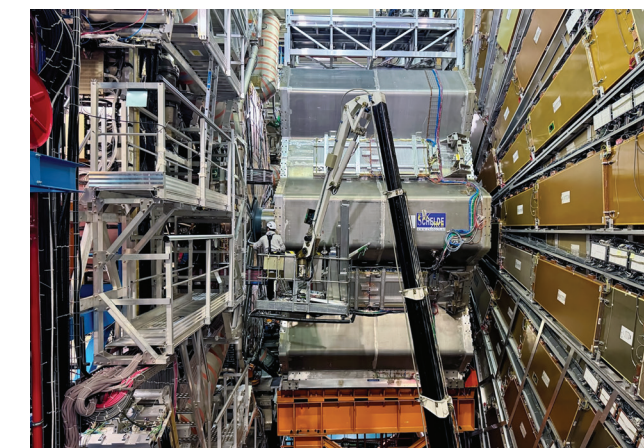
My best overall advice: Start applying early, and don't get discouraged! International programs have a different semester schedule. Many have application deadlines in early December and early June. You'll likely get a lot of rejections, a lot of nonresponses. But keep applying, and keep improving your CV, motivation letters, and interview questions with each application.

On the practical side, be sure to budget for moving costs and passport and visa fees! I had to drive 10 hours for my visa interview—this can't be done for free. Setting up banking can also be an issue. No bank in Germany would let me open an account without a German address, but I couldn't get an apartment there without a non-US bank account. These catch-22 situations are common when doing paperwork for an international grad school program, so you'll have to set aside time to find solutions.

Reddit pages can be useful when trying to gauge the foreigner experience in different towns. Also, some knowledge of the town itself—claims to fame, important history—is useful to show supervisors that you consider an interview for that particular program a privilege.

If you happen to be queer, keep in mind the laws, paperwork, and healthcare of the country you're looking into. Check out the departments' student pages for evidence that openly queer people are at least tolerated. The fact that you're queer shouldn't come up in interviews, but some countries and some departments will be less accepting than others, even in a field such as physics.

And finally, don't neglect the lesser-spoken-about countries! I found some really good programs in Slovenia and Poland, and I have friends who've found nice programs in Norway, South Africa, Argentina, and Australia. //



■ **ABOVE:** A worker attends to the massive ATLAS detector in February 2026. The ATLAS and CMS collaborations (CMS is another detector at the LHC) jointly announced the discovery of the Higgs boson in 2012, and they continue to refine our understanding of the fundamental particles today. Credit: CERN.

Creating a Conference for Undergraduates, by Undergraduates

by Paige Lettow, SPS Chapter Secretary, Hillsdale College

Has your SPS chapter ever wondered what it might look like to host your own physics conference? The Hillsdale College SPS chapter didn't just wonder—we did it!

Last fall, we looked into nearby physics conferences and realized that we would be unable to attend them. “Surely we aren’t the only college in the region with this problem,” we thought. That led to the idea: If we couldn’t attend an existing conference, why not host one?

We brainstormed what we wanted out of a conference—activities, formats, and goals—and ultimately developed a rough outline that we presented to our department. Our faculty responded with enthusiasm and encouragement. With their support, we began organizing the Hillsdale College Physics Invitational for February 2026, which was to be led by and designed for undergraduate students.

We invited astronomer Will Clarkson from the University of Michigan–Dearborn to be our keynote speaker, and we organized a schedule which included student research presentations and a networking fair. In an effort to make the conference accessible to other students, we reached out to nearby colleges and universities to invite them to attend. This was a great opportunity to connect with the physics departments at other schools and welcome them to our campus to share in our love of learning physics!

While planning the conference was a challenge, it also brought students and faculty in our department closer together. Collaborating on a project of this scale was completely new to us, but it helped us to get to know one another better and build a stronger community. People in all different departments at Hillsdale College stepped in to support us. Career Services helped us to organize a job fair, and the Events team helped us set up a website. As students, it was wonderful to see how our college supported us.

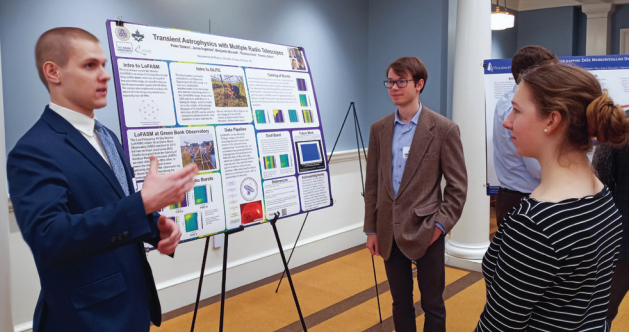
Then came the big day! One of the highlights of the conference was Professor Clarkson sharing his story and talking about his research experiences as a student and professor. He gave advice to students interested in research from both the perspective of someone who has been there and from the perspective of a research mentor. Other highlights included a lunch during which we got to talk casually with grad schools and employers and see a variety of research projects that undergraduate students are involved in.

Like any first-time endeavor, the conference had its ups and downs. We encountered a few logistical challenges—such as

forgetting to plan for water during lunch—and had some miscommunications along the way. However, these moments became valuable learning experiences, and in some cases, they even led to improvements in the conference.

Overall, the conference ran smoothly and was a rewarding experience for everyone involved.

We hope to make this an annual event that continues to grow and reach more colleges. At the end of the conference, a professor from Albion College told us he hoped to return next year. This got us excited to start dreaming up big plans for next year. If a few students walked away from this small conference with new experiences and ideas, then imagine what an impact we can make with more connections and experience under our belt! //



TOP: Conference attendees commemorate the first Hillsdale College Physics Invitational, which was planned by the SPS chapter.

ABOVE: Undergraduates share their research during a poster session at the conference. Photos courtesy of Paige Lettow.



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Cultivating a Culture of BELONGING

BRAD CONRAD HONORED WITH WORTH SEAGONDOLLAR SERVICE AWARD

by Kendra Redmond, Editor

Brad Conrad snaps a selfie with the 2022 SPS summer interns. Photo courtesy of SPS.



When Brad Conrad was four years old, his mom walked into the living room to see him, screwdriver in hand, trying to reassemble their VCR. He'd inserted a peanut butter and jelly sandwich and then taken the machine apart to get it out. "I loved knowing why things worked," he says.

Growing up, the only scientists and engineers in Conrad's life were Mr. Wizard and Bill Nye the Science Guy. But the TV personalities made a big impact, enabling Conrad to imagine a future in STEM.

High school chemistry inspired countless questions: Why are orbitals this way? Why do electrons move around? Why does this pH do that? Conrad loved the subject, but the chemistry teacher kept sending him over to the physics teacher for answers. "And eventually," he says, "I just stayed in the physics room."

With a physics bachelor's degree in mind, Conrad began exploring colleges on his own. Higher education wasn't on his parents' radar, and his high school didn't offer much support. The guidance counselor told Conrad he wasn't smart enough to become an engineer and suggested he drive trucks. Fueled by determination, Conrad went on a week-long, solo road trip, visiting colleges in several states. He eventually settled on Rochester Institute of Technology (RIT).

"You belong. You matter."

"I had no clue how I was going to pay for it," he says, "but I had my heart set on going and becoming a scientist and making the world a better place."

College offered a chance to explore the world in a way that wasn't possible in small-town Pennsylvania, he says. He embraced that, but the coursework was difficult and the dreary Upstate New York weather was challenging. During one break from classes, Conrad was on the verge of transferring to another school when his phone rang. His SPS Advisor, John Anderson, wanted to know if Conrad would plan a social event and field trip for the return to campus.

"That call from John made me feel like I had a home," he says. "That people would miss me if I wasn't there, and that I belonged somewhere." He stayed. And that experience has stayed with him.

After RIT, Conrad earned a physics PhD at the University of Maryland. Graduate school "was one of the best times of my whole life," he says. Then came a National Research Council fellowship position at NIST, the National Institute of Standards

and Technology, and about a year later, a faculty position at Appalachian State University in North Carolina.

Although he knew little about the school when he applied, Conrad fell in love with Appalachian State while visiting. He spent six years immersed in the physics department there, teaching, doing research with students, co-mentoring the SPS chapter, and building community. He revived a long-dormant science of sound course for nonmajors that flourished as a two-semester sequence, regularly maxing out enrollment at 72 students. And then, the same week he was awarded tenure, he received a job offer he couldn't pass up: director of SPS and Sigma Pi Sigma, the physics and astronomy honor society.

During his eight years as director, Conrad poured his energy into encouraging, inspiring, and advocating for physics and astronomy students and departments across the country—and beyond. He built new programs, fostered new partnerships, secured new student support and opportunities, mentored countless student leaders, and centered the student voice within the broader physics community. Through it all, his message to students was simple: You belong. You matter.

Today, Conrad is the inaugural workforce development manager in NIST's Office of Advanced Manufacturing. In that role, he helps the advanced manufacturing industry identify the skills it needs in employees and works with partners to help

students and job seekers develop them. In a nutshell, "I help people get the skills they need to get really awesome jobs in STEM," he says.

For his exemplary level of commitment and service to SPS and Sigma Pi Sigma, the SPS Council surprised Conrad with a rare Worth Seagondollar Award in June. //

ABOUT WORTH SEAGONDOLLAR

L. Worth Seagondollar spent 40 years as a physics professor and advisor of Sigma Pi Sigma, the physics and astronomy honor society, first at the University of Kansas and then at North Carolina State University. In the 1960s, he was instrumental in creating the Society of Physics Students. The Worth Seagondollar Service Award was established in his honor in 1996, and he was the first recipient.

Discovering a Kink in the System

by Nikita Mazotov, Winner of the 2025 Physics and Astronomy Congress Poster Competition, and Past SPS Chapter President, Yale University

The phrase “whatever is not forbidden is compulsory” is commonly attributed to physics Nobel laureate Murray Gell-Mann and taken to mean that any imaginable process is possible unless something explicitly prevents it from occurring.

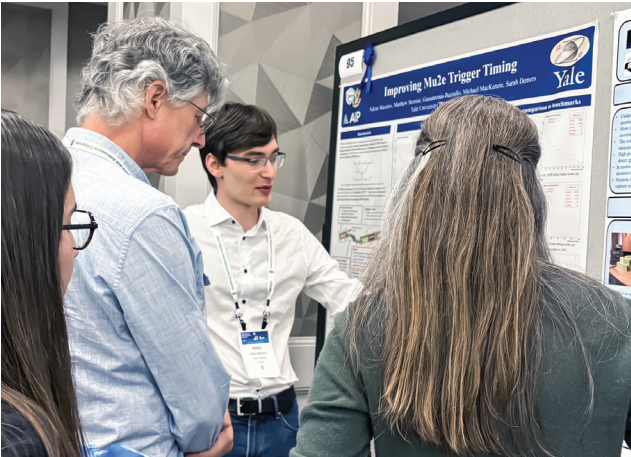
Why does a rock thrown upwards not fly into space and hit the moon? Because it doesn't have sufficient velocity to overcome the Earth's gravitational potential. Why does an iceberg not sink? Because the density of ice is less than that of water, and buoyant forces keep it afloat.

In particle physics, we ask a parallel question: If neutrinos and charged leptons (which include electrons, muons, and taus) are part of the same lepton “family” in the Standard Model (SM) of particle physics, and neutrinos spontaneously change from one type into another through oscillations, why don't muons spontaneously become electrons?

I don't know. In fact, no one does. This is a hypothesized phenomenon known as charged lepton flavor violation (CLFV). It's an open mystery of particle physics.

When I started a physics major, “SM” and “CLFV” were just combinations of letters to me. My heart wasn't even set on sticking with physics. What I did know, however, was that I needed a job to fund my bubble tea consumption. I approached my introductory physics professor, Paul Tipton, about getting a job and ended up working for CERN's ATLAS experiment. And it was only by participating in research, making decisions, and posing my own questions to investigate that I really understood the appeal of the physics path. I have never looked back.

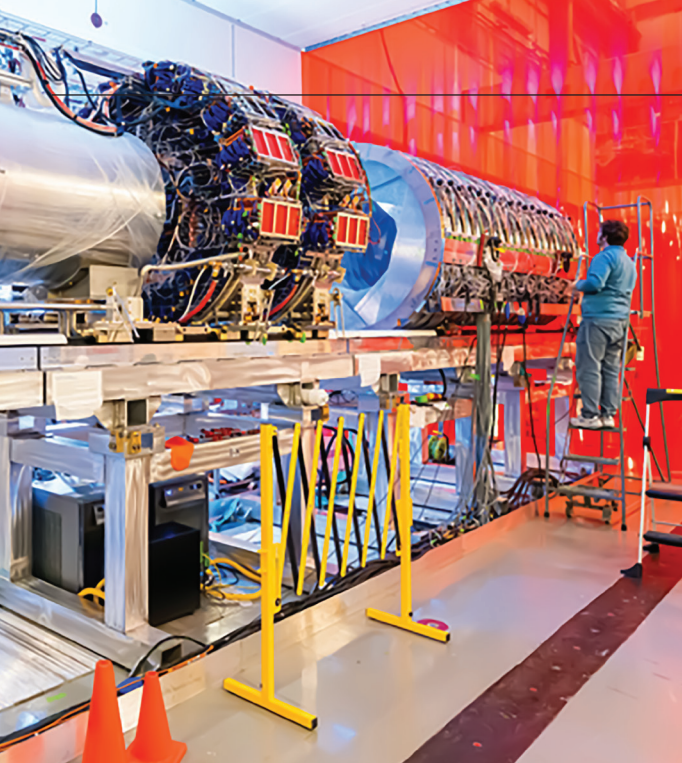
While I do have many stories about ATLAS, this story is about my work in Professor Sarah Demers' Mu2e group. Mu2e is an



TOP: Installation of the Mu2e experiment detector system, which includes the tracker and calorimeters, continues at Fermi National Accelerator Laboratory. Learn more about Mu2e at mu2e.fnal.gov. Photos by Ryan Postel, Fermilab.

ABOVE: Nikita Mazotov presents the award-winning poster at the 2025 Physics and Astronomy Congress. Photo courtesy of Mazotov.

upcoming experiment at Fermilab, a particle physics lab in Illinois, designed to look for evidence of CLFV. In particular, we're looking for the spontaneous conversion of a muon to an electron without the emission of a neutrino (“mu to e” is where the experiment gets its name). This process is not explicitly forbidden in the equations that define our understanding of SM physics. The uncharged



partners to muons and electrons—the muon neutrino and the electron neutrino—go back and forth all the time as they travel through space. You would expect similar behavior from muons, yet it has never been observed.

We do see muon-to-electron conversions that involve a muon neutrino and an electron antineutrino in, for example, atmospheric muons. This “normal” (neutrino?) muon-to-electron conversion happens countless times a day, but the Standard Model predicts the conversion without neutrinos to happen 10-50 times less frequently—a level that is experimentally undetectable. Many extensions to the Standard Model predict that the neutrinoless conversion ought to be more frequent, but it has been lurking at sensitivities below what Mu2e's predecessors could observe. It might be just within reach of modern experiments like Mu2e.

Since the target process is so rare, Mu2e must observe a lot of muon decays, hoping that one of them might be the one. As you might expect, observing every decay and writing it to a hard drive would require an impossible amount of storage space, which is why the experiment employs an online trigger—software designed to look at each event as it's happening and decide if it might be interesting. This places two key constraints on the trigger:

- The trigger must run really fast
- The trigger must maintain a high efficiency to not miss any of the already-rare target process

When I joined Mu2e, the trigger was working really well most of the time, but certain events would lead to significant delays, and no one knew why. I was tasked with figuring it out.

By then, I had already been working in particle physics research for two summers, so I thought I was reasonably competent. This illusion was shattered when I was immersed in an entirely new ecosystem of code written in C++, which I had not worked in before. With the help of the amazing mentors in my research group, we

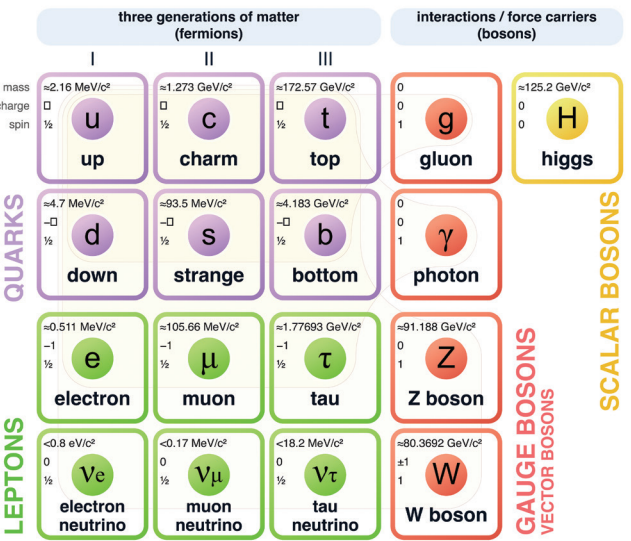
embarked on the long process of learning how the system worked so I could eventually help make it better.

When I was up to speed, I analyzed each of the individual trigger modules that work together for particle detection to determine which ones were delayed. Once I narrowed down the cause to one, I timed the performance of each step in that module's code, edging closer and closer to the answer. Ultimately, I realized we could run a step of the pattern recognition algorithm fewer times, since some of the incoming data corresponded to protons—particles the detector was not supposed to be looking for—and could therefore be filtered out by the characteristic energy deposited. This change improved the speed of the entire trigger sequence by 15% at no cost in efficiency, mainly by speeding up many of the events that used to take a long time to process.

In the paragraph above, I described a year of research, which spanned a summer working at Fermilab and my senior thesis. And implementing the change was the easy part. Diagnosing the problem and coming up with a solution was where the time really went. Looking back, I'm tempted to feel a little dumb—if the problem can be summarized so succinctly, why had it taken me a year to solve? But such is the physics experience. We needed to try lots of things that didn't end up working before we finally ironed out this tiny kink, which is only one of many.

And the analogy is broader. The Standard Model is incredibly successful, but it also has some kinks. Sometimes it feels like, since the discovery of the Higgs boson, we haven't found any new solutions. But we keep looking. Mu2e might find evidence of CLFV or it might not. But through knowing what doesn't happen we can zero in on what does. There are only so many places for the answers to keep hiding. //

Standard Model of Elementary Particles



ABOVE: The fundamental particles according to the Standard Model (SM) of particle physics.

APPLYING TO GRAD SCHOOL

in a Time of Uncertainty

by Kendra Redmond, Editor

Applying to graduate school is a big decision. That may sound obvious, but many physics and astronomy majors apply to grad school because they feel like it's what they're supposed to do. But it's YOUR future—take the reins!

With a foundation in physics and astronomy, you're already primed for a wide variety of careers. Some of them require or benefit from a graduate degree in one of those fields, others from a graduate degree in engineering, education, medical physics, or another related field. And still others are wide open to those with a bachelor's degree. It's important to spend time thinking about what you want for your future, and what will help you get there.

You should also know that the landscape of graduate admissions is currently in flux. In the United States, the federal government is the primary funder of basic scientific research at universities. These dollars support everything from lab space to equipment, operating costs, and personnel, including graduate student stipends. But over the last 18 months the government has cancelled, delayed, and rescinded science grant allocations at levels that have alarmed the scientific community. And the administration has requested dramatic cuts to science funding agencies for the 2027 fiscal year, which begins in October. The situation has left many physical science graduate programs uncertain about how to plan for the future.

Another complicating factor is that changes to visa and immigration policies are making it harder for some international students to get visas to study in the country—even if they are accepted by programs—and assurance that they can stay in the US long enough to complete a PhD. (For the latest science policy news, see aip.org/fyi.)

The massive uncertainties around federal funding and international students are "making admissions challenging for both students and departments," says Steven Rolston, chair of the physics department at the University of Maryland.

Many departments are accepting fewer graduate students. A preliminary report by the American Institute of Physics (of which SPS is a member society) indicates that in 2025, physics graduate enrollment declined by 7–9%, primarily driven by funding concerns.

"Most [department] chairs believe the decline in enrollment, both among US citizens and non-US citizens, will continue, and be even larger, in 2026," according to the report.

Even PhD programs that haven't lost funding yet are being cautious; they don't want to accept students for a 6–8 year program and not be able to support them through the finish line. "We don't want to be in a situation where someone's fourth, fifth, and sixth years are coming up and it's not clear how to fund them," says Jonathan Fortney, chair of the Department of Astronomy and Astrophysics at the University of California, Santa Cruz. There's always a certain amount of risk in assuring future funding for graduate students, he says, but the situation is currently so uncertain that departments are being "tremendously more cautious."

WHAT DOES ALL THIS MEAN FOR YOU?

Programs are telling the *SPS Observer* that what they're looking for in graduate students is still the same—motivated, engaged students who demonstrate interest in their specific program and are likely to succeed. With all of this in mind, here are some tips for moving forward.

1 Explore a variety of options

If graduate school is a vital part of your future plans, go for it! Approach the application process with flexibility and creativity. Apply to a variety of programs, not just the top results in online searches. Look for lesser known programs with a track record in your field to broaden your options, and consider international programs, masters degree programs (not just combined masters and PhD programs), and programs in fields such as materials science, engineering, and atmospheric physics.

2 Do the basics well

Invest time in writing an effective CV and personal statement. Look for gaps in your skillset and fill them in. Complete your applications early and ask mentors, friends, and your career center to give feedback. Remind your letters of

recommendation writers about projects you've worked on together and challenges you've overcome to help them write strong letters. (For expert advice on these tasks, see page 25.)

3 Do your research

Applications that are personalized *to the program*, demonstrating how your research interests align and that you could see yourself being successful *in that program*, will stand out to admissions committees. Take the time to seriously investigate each program on your short list and revise your application package accordingly.

4 Seek external funding

Coming in with a fellowship can make you a more attractive candidate. Investigate fellowships in your field early—they often have application deadlines earlier than graduate school programs. Invest time and care in your applications and work with your research advisors and mentors to create the strongest possible package.

5 Be flexible

Admissions committees consider a range of factors in their decisions, including those unique to their program and funding landscape. Many have far more qualified applications than positions. Rejections don't mean that graduate school isn't for you, but in this uncertain time, getting into your top program, or any program at all, may require more patience and persistence.

If things don't work out as you hoped, it's okay to be disappointed. Bridge programs, which help students bridge the gap between undergraduate programs and PhD programs, can be great options and often have spring deadlines. Another common path is to work in a lab for a year or two and reapply. Many new graduates take a year to unwind from academia and focus on their applications, strengthen their skills, or gain work experience outside of a lab—all of which can enhance grad school applications. Still others begin teaching or working in industry, find that they love the work, and decide not to reapply. You have options. //

GRADUATE STIPENDS & FELLOWSHIPS

Most physical science graduate students don't pay for a PhD. Instead their tuition is waived and they receive a stipend—a fixed amount per year paid as a salary—to be a teaching assistant or research assistant.

Graduate fellowships are merit-based awards given to individuals. They typically cover the cost of graduate school and provide a monthly stipend for three years. That means fellows enter a graduate program with their own funding; they don't need a teaching or research assistantship from the department until later in their tenure.

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Department of Physics and Astronomy

Raleigh, North Carolina
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- Total research funding: \$3,600,000
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Apply: <https://bit.ly/4fgNTeV>

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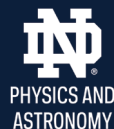
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Visa and Immigration Policy: What's Changing?

- Global talent has long powered U.S. science and engineering
- Shifting policies are reshaping that foundation
- Access our policy guide for the latest developments in this changing landscape



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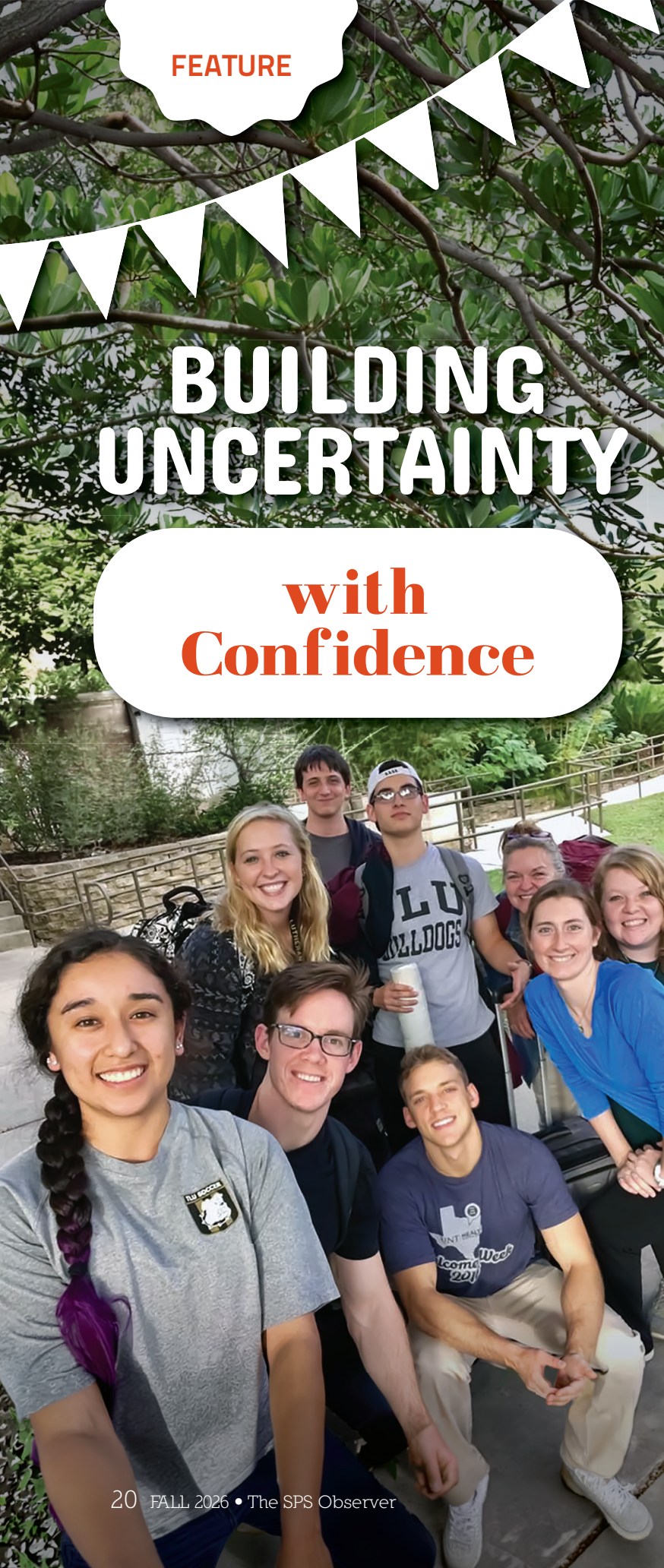
FAIRFAX, VIRGINIA

[PHYSICS.GMU.EDU](https://physics.gmu.edu)



BUILDING UNCERTAINTY

with
Confidence



by Toni Sauncy, Professor Emerita, Texas Lutheran University, and Patent Examiner, United States Patent and Trademark Office

Perhaps the most anticipated, expected, and, for some, terrifyingly dreaded questions asked of an undergraduate student nearing graduation is...Now what? The potential answers are nearly endless and largely based on the level of certainty—or uncertainty—one has about their choices or options.

Having spent an entire career advising, mentoring, and building community with physics and astronomy undergraduates, I have some insight into what will likely come next for many students. As my list of “formers” grows, so does the confidence that my standard answer to another often-asked question—What can I DO with a physics degree?—is not hyperbolic. The answer has always been: **anything you want**. And, after almost three decades, I have the receipts, so to speak.

While earning a degree in physics or astronomy requires ingesting an amazing amount of fundamental physics knowledge on a grand scale, the real gain is a certain set of skills that ranges from the very practical to the more mysterious ability to conceive of the mind-blowing what-ifs of the universe. That special skill set is based on learning how to think boldly, to ask shamelessly, and to pursue solutions persistently. Physics and astronomy students discover how to creatively envision a route through a complicated problem that may, at first glance, seem impossible, but which is made manageable by careful dissection into smaller problems that eventually yield the bigger solution. In short, earning a degree in physics means you are capable of **anything**.

The range of life success available to physics and astronomy students is evidenced by the many ways my formers, many now lifelong friends, make the world a better place. Like many academics, in the early days of my career, I thought my job was to pave the way for each and every one of my students to enjoy a wonderful and satisfying dream life in academia! I soon became enlightened. The most important thing is to make sure every student is prepared for their **personal anything**.

The great privilege of being at the front of a classroom full of brilliant folks who sometimes enter higher education with clear ideas of what they are “going to be” is witnessing the melting away of that certainty as they begin to realize how much they don’t know. But it’s also watching them grow in their ability to choose from among an enormous and expanding list of possibilities, to see them struggle to decide what comes next not

because they are ill-prepared but because there are so many options. They have experienced what an “anything you want” career menu looks like.

Many of my students did choose to pursue advanced degrees, but few in “regular” physics and astronomy. Some felt a pull to change the world one patient at a time through medical physics. Others pursued degrees in the full range of engineering fields, and several even trepidatiously approached me with the question, **What would you think about me going to law school?** And then did and are now practicing attorneys.

Many more students timidly approached me with, **What if I don’t want to go to grad school?** And then didn’t. Instead, they found an amazing array of satisfying, rewarding careers. They ensure the safety of water sources and US military personnel. They are data scientists, analysts, accountants, and electronic warfare engineers. They do fundamental research, improve electronics manufacturing, and develop new scientific instrumentation. They work in fields that required them to learn more biology, coding, or advanced analytical chemistry

skills. And they succeeded because they were prepared to lean into the uncertainty, to learn something new and different. Because they were open to tackling whatever problems were set before them and confident in their ability to handle the unknown.

More impressive than the work they’re compensated to do or the well-known companies they work for are the many ways my former students use their undergraduate physics experience to be great parents, community volunteers, leaders, and good people. Many carry forward the wonder they learned as undergraduates. There’s a military veteran, now a high-tech augmented reality guru, who’s the cool dad doing physics demonstrations, learned from SPS outreach, at his children’s school. The engineer who helps make potable water a reality for villages around the world. The dedicated animal welfare volunteer. There’s the business-owning welding genius; the daycare manager; the stay-at-home parents; the plethora of technicians and IT professionals; the attorneys; the environmental, electrical, and aerospace engineers; the materials scientists; the radiation physicists; the community college educators; and

yes, even the researching, PhD-producing academics.

Among my formers are also those who bravely let me know they were not going to finish the grad program they started—apologizing, somehow thinking they were letting me down—who moved on to better fits, to their own **personal anything**, and to happy and rewarding lives. These are the stories that haunt me, because the most important thing to me is that every student graduates with the confidence to decide what is best for them, their families, and their futures.

I hope that every advisor, mentor, and educator out there thinks likewise. I have every reason to believe that most do. We love physics. We love more the people who share our fascination with amazing things and are comfortable with the inevitable lesson of physics—that there is always more we do not know and will never have enough time to know.

Whatever you decide to do with your physics experience, be open to your uncertainty and let it buoy confidence in your capacity to succeed. If my collection of receipts is any indication, the odds are in your favor. //

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LEFT: Toni Sauncy (back row, far right) and a crew of Texas Lutheran University students commemorate their journey to the 2016 Physics Congress. Photo courtesy of Sauncy.

ADVICE FROM Those Who've Been There

During graduate school panels at the 2025 Physics and Astronomy Congress, current and recent grad students shared tips and advice with attendees. Here, some of the panelists weigh in on how to find a good fit in a program and how to settle in once you arrive.

What Do You Want in a Grad Program?

by Stephanie Howell, Physics Graduate Student, University of Oregon

Deciding on a graduate program can be overwhelming, especially while juggling demanding coursework, research, or whatever else you may have on your plate before graduating. Of all of the advice I received, here's what stuck with me the most:

- 1 What you plan to do after graduation matters. Are you hoping to go into academia? Industry? Teach high school? Ask yourself if the program you're considering will adequately prepare you for your intended career path.
- 2 What you want to prioritize while in graduate school matters. Different programs have different cultures. Do you thrive in a competitive environment, or do you prefer something more collaborative? Are you willing to meet the workload requirements for a demanding program, or are you looking for an environment with a stronger emphasis on work-life balance?
- 3 Where you live matters. If you're planning to get a PhD, that will take roughly six years. You want to like where you live! If you're given the opportunity to visit a prospective program, go and ask yourself, "Can I really see myself living here?"

Remember, your experience in graduate school is supposed to serve you. Make your decision based on what you feel is best for your needs, not what you think is expected of you!

Make the Most of your PhD Experience

by Marisa Petrusky, Aerospace Engineering Sciences PhD Candidate, University of Colorado Boulder

With respect to PhD programs, remember that you're in it for the long haul! People say the typical time to complete a PhD is four to six years, but STEM candidates very rarely finish in four. Sometimes research will progress quickly, and other times you may be stuck for months. Both periods are equally important to the research process and to your personal growth as a scientist or engineer.

Be patient with yourself and your work. Try not to compare yourself to others or adhere to expectations of what you think a PhD program is going to be like. And, when possible, enjoy the perks of grad school life—exploring a conference location, auditing a class for fun, or making friends from all over the world. The work will always be there tomorrow!

Research Potential Advisors, and Know You're Not Alone

by Brianna Hauke, Atmospheric Science Graduate Student, University of Wyoming

As you work on graduate school applications, figure out which advisors you wish to work with. What is their advising style? How much time do they devote to their students? Are they very hands-on? Do they meet with students weekly or monthly? See if you can get information from current students as well; they may be more honest than professors about these questions. Also look into what the program requires of students. Some programs have dropped GRE requirements and qualifying exams.

Once you enter a program, it can be a bit daunting to make new friends. Remember that within your cohort, you will all have many of the same struggles with graduate school—especially as you tackle core classes. I found it very helpful to work on homework with my fellow first-years, and to ask students with more experience and knowledge for help. And make sure to find a third space outside of your office and classroom; don't make graduate school your whole life! //



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www.southernct.edu/program/applied-physics-ms

TIMELINE FOR APPLYING TO GRAD SCHOOL

with Reflection and Intention

by Kendra Redmond, Editor

COMMONLY REQUIRED APPLICATION MATERIALS

- Application form
- Résumé or CV
- Written essays (e.g., personal statement or research statement)
- College transcripts
- Letters of recommendation

Depending on the program, entrance exams such as the GRE general test, a GRE subject test, or an English proficiency test may also be required.

LEARN MORE

Check out these *SPS Observer* articles for expert advice on graduate school.

- Graduate Programs 101 students.aip.org/observer/graduate-programs-101
- Who Pays for Grad School? students.aip.org/observer/who-pays-for-grad-school
- Finding Great Grad Programs for You students.aip.org/observer/finding-great-grad-programs-for-you
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- How to Write an Effective Statement of Purpose students.aip.org/observer/how-to-write-an-effective-statement-of-purpose
- Your Guide to Grad School Visits students.aip.org/observer/your-guide-to-grad-school-visits

This is a suggested timeline for exploring your post-bachelor's degree options and, should you decide to do so, applying to graduate programs. The timeline assumes a four-year, eight-semester undergraduate experience that begins in the fall. Many students don't follow this route. If you're one of them, simply adapt this timeline to work for you. If you're already well into your program, have no fear! Just adapt this timeline to fit the time you have left.

Semesters 1-4: Dig In

In your first and second years as an undergraduate, focus on developing skills, digging into the basics, and completing your problem sets. Do research, go to conferences, attend job fairs, and talk to people about their careers and backgrounds.

Semester 5: Explore

You're in upper-level classes now and may be getting a taste of research. What are you enjoying most? Is it studying certain subjects, applying specific skills, or researching the unknown? Spend this year trying new things: present posters, teach science lessons to kids, build a robot, and visit labs. Ask people what graduate school is like, and explore the many kinds of graduate programs that are out there. *Hint:* You can apply to more than just physics and astronomy graduate programs! Look into adjacent fields like biophysics, medical physics, science writing, and engineering. Also, go to job fairs and ask who hires physics majors. Find out what your department alumni do and how they got there. What are you most passionate about?

Summer Before Semester 7: Prepare

You deserve a break after wrapping up finals, but don't let it last all summer—this is key prep time. Research your list of programs, see if they have faculty doing research that interests you (and reach out to them!), and reflect on whether you could see yourself in that program, location, and lab. Then decide which programs you'll apply to and examine their applications. Draft your statements and responses to all prompts, and update your résumé or CV. Ask faculty members and mentors for feedback on your drafts and revise them. This is also the time to plan for application-related expenses (application fees, entrance exams, transcript requests, etc.) and, if cost is a barrier, request application fee waivers from programs.

Semester 8: Take the Next Step

Breathe. Remember that no matter the outcome, you won't be out of options. You may be invited to participate in interviews or site visits or simply receive letters noting whether you've been accepted. If you receive offers, consider your options, revisit your values, and decide what's next for you. If you don't receive offers, know that you're not alone, and take some time to reflect on a path forward. This is a tough time to apply, and graduate school can definitely still be in your future! See page 17 for some advice on what to do if you don't get in. //

Semester 6: Imagine and Reflect

Try on the idea of another 2 to 8 years of in-depth study and research. Can you see it? How does it feel? Consider your career and life goals. Is grad school required, preferred, or not necessary? If you're drawn to the grad school path, browse programs on [GradSchoolShopper.com](https://gradschoolshopper.com) and other sites, and talk to everyone you can about their experiences. Reflect on your values and identify what you're looking for in a program: size, location, department culture, research specialties, and financial assistance. List programs that interest you, check their requirements, and make sure you're on track to meet them. If entrance exams are required (like the general GRE or subject GRE), schedule them and make a study plan. Also look into fellowships and scholarships.

If grad school sounds less than compelling or isn't required to reach your goals, you might decide to exit this timeline now. That's totally valid and commendable—it's *your* future! Prepare for the job search by interviewing people with careers that pique your interest. Research who's hiring physics and astronomy majors, attend career fairs, participate in professional development workshops on résumé writing and interviewing for jobs, and network, network, network.

Semester 7: Apply

Most US graduate school applications are due in late fall for the following academic year, which can be difficult to juggle with finals and end-of-semester projects. Work on your applications early and consistently (and thank yourself for starting over the summer!). Make a spreadsheet to track the status of program requirements and deadlines. Request your transcripts, exam scores, and letters of recommendation early. Finalize your personal statement and essays for each program, your résumé, and other materials. Ask the writing center or a friend to proofread everything, then submit your applications! Make sure all of your letters of recommendation are submitted, and don't be afraid to nudge writers if a deadline is looming.

BETTER TOGETHER

Are your friends or SPS peers applying to graduate school at the same time as you? Make it a group effort. Plan regular working sessions to hold each other accountable—with snacks! Consider themed sessions, such as résumé writing or editing personal statements, and invite faculty members, alumni, or your school's career center to provide advice and feedback. You can also bring along tips from past *SPS Observer* articles and use them for reference.

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A Nontraditional Path:

REIGNITED CURIOSITY LEADS TO INTERNATIONAL STUDIES

by Joshua McNeill, Recent Graduate of a Dual-Degree MS in Engineering Physics, Appalachian State University, and MS in Engineering, Management Center Innsbruck, Austria

Growing up in North Carolina, I became interested in physics at a very young age. My father, Jonathan, would take me to a small park near the airport in Charlotte, and we would spend hours watching planes take off and land. It was the first time I recall yearning to know how something so complex worked. I have another distinct memory of watching the Opportunity rover land on Mars. Some time later, my father hung a banner in our living room with a panoramic image of the surface of Mars taken by the rover. I used to just stare at it, imagining what it would be like in person. Because of memories like these, I credit my father for always answering my barrage of questions and igniting my curiosity about the world and its inner workings.

My undergraduate experience might be described as nontraditional. For four years after high school, I didn't have much purpose or drive. Then I started to follow SpaceX's attempt to reuse rockets. I spent hours watching videos, trying to learn as much as I could about their efforts, and it helped to reignite my curiosity. At 22, I decided to start the spring semester at my local community college. I quickly fell in love with my mathematics and physics coursework and decided to take extra calculus and physics classes—any the college would offer—as electives. As I neared the end of the associate's program, my professors, family, and friends encouraged me to pursue a bachelor's degree in physics at Appalachian State University.



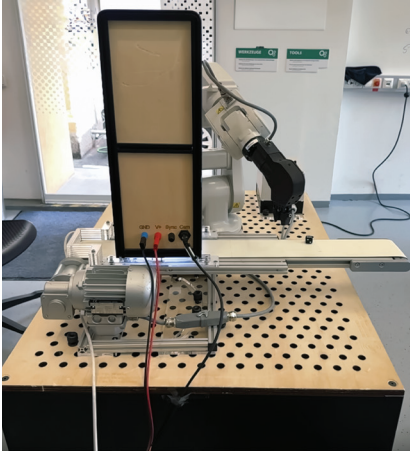
TOP: A scenic view of the Inn, a tributary of the Danube that flows through Innsbruck.

ABOVE: Joshua McNeill enjoys a hike overlooking Innsbruck, Austria. All photos courtesy of Joshua McNeill.

I started in the spring of 2021, when COVID kept classes entirely online. Along with my physics classes, and with no previous experience, I decided to take a programming class and a simple electronics class. The latter had in-person laboratory sessions with students distanced from each other and wearing masks and face shields. I didn't realize it at the time, but those two classes ultimately shaped my academic path.

Even as my physics classes got more challenging, I relished every assignment. Having transferred in with my associate's, I wasn't distracted by gen ed courses and took any elective classes I was interested in, including several more computer science courses and a couple of graduate electronics courses. Near the end of my undergraduate studies, my electronics professor, J. Sid Clements, suggested that I apply to our in-house engineering physics graduate program. The program emphasizes laboratory automation, instrumentation, and a strong foundation in electronics and programming. I applied right at the deadline and was fortunate to be accepted.

During my first year, I met two students from Austria's Management Center Innsbruck (MCI) who were in the process



ABOVE: The setup for one of the robotics projects McNeill worked on during his master's program.

"home" institution for the first two semesters and moving to the "host" for semesters three and four. The courses follow each institution's normal course schedule for a graduate student's first year in the respective program. In the fifth semester the student chooses an institution at which to write a masters thesis and complete the degree. Two versions of the thesis are written and submitted to fulfill each institution's requirements and guidelines, then a single, unified defense is given at one insti-

me, and I saw how warm and welcoming they were. Unfortunately, I neglected to travel much during my time in Austria, although toward the end of my stay I hiked a few trails with a local friend that I still speak with regularly.

For students considering a dual grad school program, I recommend reflecting on whether the courses are topics you'll enjoy. These programs can add stress and usually time to one's academic career, so if you don't enjoy the topics, it will make the experience much more difficult. I'd also advise talking to previous students to get an idea of course load, social life, living situations, and all the unexpected nuances of day-to-day living. These differences can seem small—they certainly did to me—but can quickly compound and make the experience less enjoyable. Similarly, it's important to have strong support systems, such as family or friends, to help you manage some of the stressful experiences that will inevitably occur.

Having completed my program, I'm eager to bring together my experience in mechatronics, electrical engineering, physics, and computer science. I'm seeking roles in aerospace or similar fields, motivated by work that blends disciplines, encourages collaboration, and gives me a

"Studying abroad is a transformative experience—being immersed in different cultures, meeting new people, taking in scenic vistas."

of earning dual degrees from Appalachian State's engineering physics program and MCI's mechatronics program, focusing on electrical engineering. I took a couple of classes with the students and worked as their teaching assistant in several others. I didn't anticipate taking part in the program myself, as it felt too far out of my comfort zone. But as I progressed through my first year, Professor Clements reached out. He thought I would be well suited to the topics being taught at MCI. I took almost an entire semester to think it over and ultimately decided to apply. I knew it would be advantageous for my future, would provide unique experiences, and would allow me to learn topics not offered at App State.

The program typically takes five semesters to complete. Students study for one year at each institution, starting with their

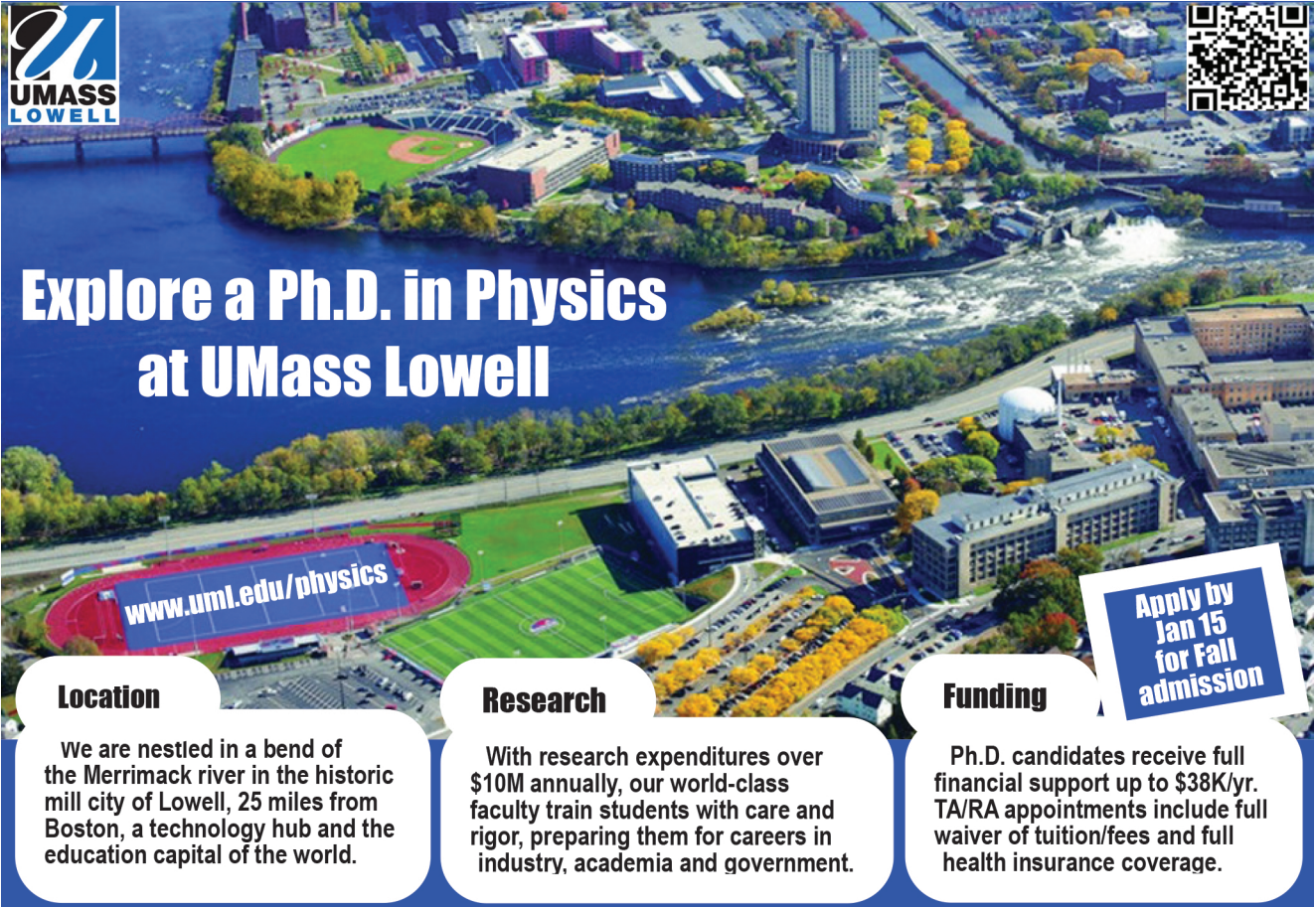
tution, with the other participating online. MCI also requires an oral masters examination during which the student answers questions about their MCI courses. Once all the requirements are met, the student is awarded both masters degrees.

As many others will say, studying abroad is a transformative experience—being immersed in different cultures, meeting new people, taking in scenic vistas. Some of the drawbacks I experienced were related to my introverted nature. I struggled to make close friends for the first couple of months, mainly because of the language difference. Students frequently socialized in German, which I don't speak. This made it difficult to step into a conversation without feeling like I was interrupting or forcing a switch to English. But after some time, several students chatted with

meaningful role in solving complex problems and driving a project from concept to completion. I also plan to someday return to Austria to spend more time with the friends I made and to travel, hike, and generally just enjoy the scenery.

My academic experience would never have been possible had it not been for the support and encouragement of my father, professors, classmates, and friends. I originally aimed to simply earn an associate's degree and find a somewhat fulfilling job. But thanks to their influences, I've accomplished more than I ever thought possible and had the best time of my life so far.

Don't be afraid to say yes to opportunities. You never know what doors they may open and what paths they will lead you down. //





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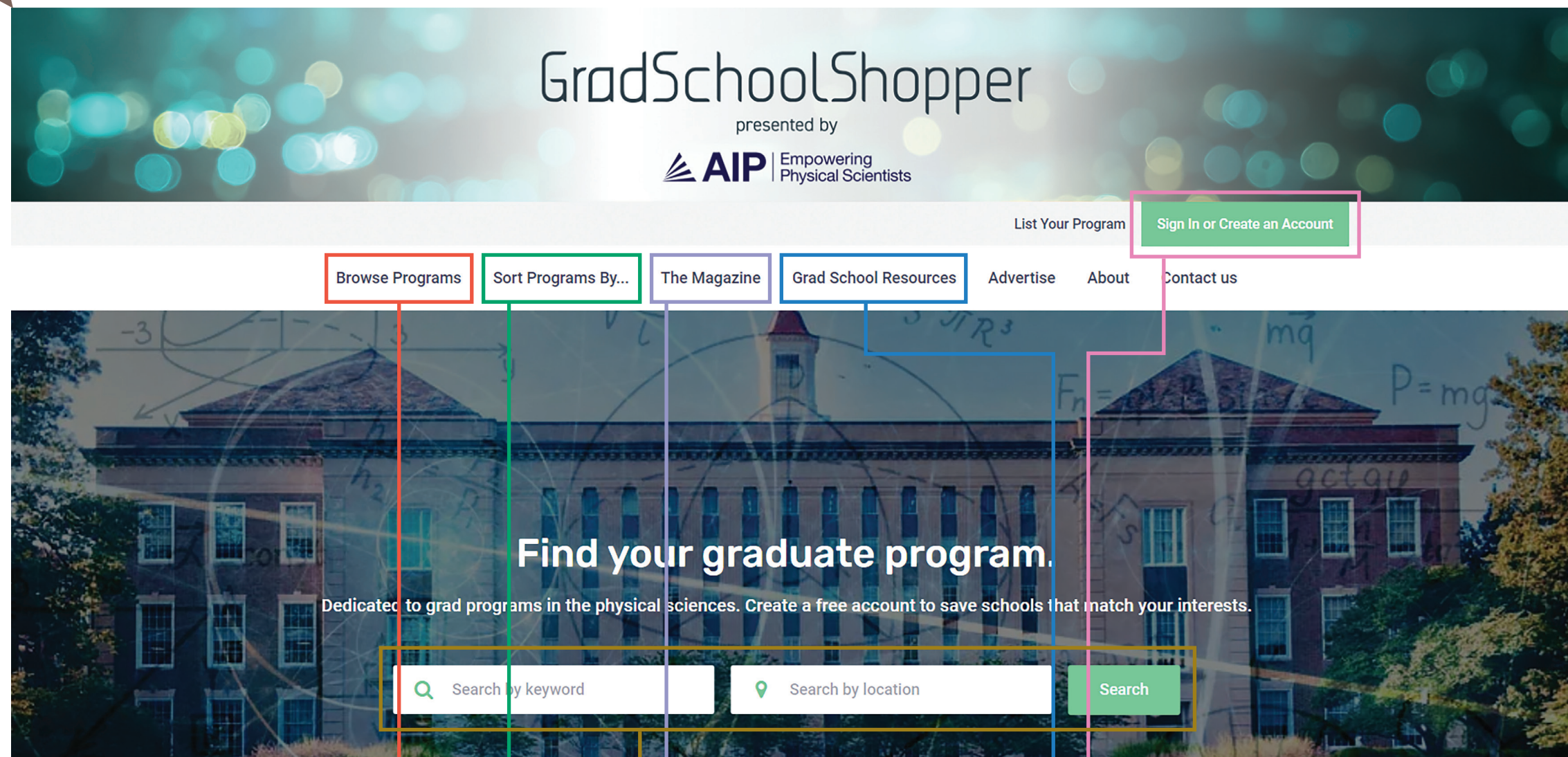
Simplifies the Grad School Search

The online resource for graduate programs in physics, astronomy, and related fields

by Kendra Redmond, Editor

Searching for the right grad program can be time consuming, but it doesn't have to consume you. In support of physics and astronomy students and the future of the physical sciences, the American Institute of Physics hosts [GradSchoolShopper.com](https://gradschoolshopper.com) (GSS), a free online resource for browsing, sorting, and comparing hundreds of graduate programs in physics, astronomy, and related fields. GSS is an official partner of *Physics Today* and the Society of Physics Students (and this issue of the *SPS Observer*!).

The backbone of GSS is an extensive and searchable collection of graduate program profiles. Each profile includes, at minimum, a list of research specialties and contact information. Many programs have enhanced profile pages that provide an overview, application requirements, a description of the department culture, quick links to relevant web pages and social networking pages, and even videos and photos.



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Before GSS and SPS partnered on the Fall issues of the *SPS Observer*, GSS had its own magazine. You can check out past issues here.

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GRAD SCHOOL RESOURCES

Here you'll find links to graduate school-related resources, including lists of physics bridge programs, the latest data on physics and astronomy graduate education, *Physics Today* career issues, and many related organizations and reports. //

This piece originally appeared in the Fall 2024 issue of the SPS Observer.



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SPECIAL FEATURE

That Special Summer Before Grad School

Compiled by Rianna Ehrenreich, SPS and Sigma Pi Sigma Programs Engagement Associate

Whether you're getting a head start on research, saving up for a potential move, or giving yourself a mental break, there's no wrong way to spend the summer before graduate school. Here's how a few members of Sigma Pi Sigma, the physics and astronomy honor society, spent that special summer.

Note: Some submissions have been edited for length and clarity.

"I spent my time working at a local grocery store to save up money for my first month's rent and the general expenses of moving across the country. I also made sure to spend a lot of time with my family before moving away! While I had the opportunity to start research early over the summer, it was important to me to be as financially and emotionally prepared as possible before starting graduate school."

- Jasmyne Emerson was inducted into Sigma Pi Sigma at Seton Hall University in 2021 and is a graduate student at Purdue University

"I resumed my position as a research student under the wing of a therapeutic medical physicist in the Radiation Oncology Department at the University of Miami Sylvester Cancer Center. . . This early start definitely helped get my graduate school projects off the ground, enriched my understanding of the technical and clinical aspects of the impacts of this work, and has continued to influence my research interests as a practicing board certified clinical medical physicist."

- Nellie Brovold was inducted into Sigma Pi Sigma at St. Olaf College in 2017 and obtained an MS at the University of Miami

"I was busy with a lot of non-science activities. I hung out with friends at the pool and Lake Erie beaches, scooped ice cream at my food service job, and helped a friend train for a marathon by accompanying them on a lot of long runs. I also remember preparing for my move from Ohio to Texas—scoping out housing online from afar and contacting potential roommates, along with making my Ikea furniture shopping list. . . I encourage students to make sure to take a break. You'll have a long 4, 5, 6-plus years to dive into your PhD and may be doing science much longer beyond graduate school! You also may be moving far from friends and family. It's good to come in fresh. So maybe that marathon training helped me in more than one way that summer, since a PhD is a marathon, not a sprint!"

- Lydia Kisley was inducted into Sigma Pi Sigma at Wittenberg University in 2010 and obtained a PhD at Rice University

"Luckily, I did not have to find a summer job outside of my field, as I was able to be paid as a pseudo-undergraduate researcher, having matriculated but not yet officially started graduate school. . . It was a really important experience for me; it led to me being able to publish a moderately impactful paper on g-mode oscillations in neutron stars much faster than I would have been able to without having spent that summer developing a deeper understanding of the field. . . If I had taken the summer off, I don't think I would have been as ready as I was to transition to graduate work. I was, and still am, very grateful for that experience."

- Alexandra Semposki was inducted into Sigma Pi Sigma at Ohio University in 2018 and obtained a PhD at Ohio University

continued on page 34 →

“I spent the summer before graduate school working as a residential teacher at the Cardigan Mountain School in New Hampshire. . . I also made an effort to spend time with family, as moving across the ocean to the UK was a huge step academically and personally! It was a time of reflection, excitement, and growth, and I encourage anyone headed into such a period to take a moment to enjoy it. The pre-grad school summer is a special few months, so make sure you pause to look around and take it all in.”

- Connor Pickett was inducted into Sigma Pi Sigma at Embry-Riddle Aeronautical University - Prescott in 2021 and is a graduate student at the University of Surrey

“I moved across the country to my grad school and was able to secure a summer research position. It opened up research collaborations before the pressure of classes and qualifiers began. Plus I was able to meet the older grad students and settle in!”

- Amy Simon was inducted into Sigma Pi Sigma at Florida Institute of Technology in 1992 and obtained a PhD at New Mexico State University //



SIGMA PI SIGMA

Sigma Pi Sigma exists to honor outstanding scholarship in physics and astronomy, to encourage interest in physics and astronomy among students at all levels, to promote an attitude of service, and to provide a fellowship of persons who have excelled in physics and astronomy. Membership is for life.

The physics and astronomy honor society is closely linked but distinct from SPS. Many SPS activities are supported by donations from Sigma Pi Sigma members and the SPS Council oversees both organizations.

If you're not sure whether your school has a Sigma Pi Sigma chapter, or if you're interested in starting or restarting a chapter, reach out to your department chair or the national office at sps@aip.org.



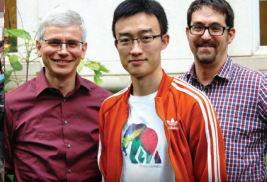
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Screaming Into the Void: Ace Your Exam, With a Side of Hot Coffee

by Brad R. Conrad, Education and Workforce Development Manager, Office of Advanced Manufacturing, National Institute of Standards and Technology

Finals. Not an easy time for any student, or professor—especially in physics and astronomy! I would wager that by graduation, every STEM student has spent tears and been compelled to scream. This is totally normal, given the time, energy, effort, and stress toll of learning to critically think and solve the unsolved.

Speaking of energy, time, and effort, we all know that sound—screaming, in this very specific case—takes energy to produce. We can think of it in biological terms, but also in terms of the energy-carrying physical waves we produce when we scream. Sound waves contain energy.

Sound waves are longitudinal pressure waves, or variations in air pressure. In this case, they're caused by a person's vocal folds vibrating at specific frequencies, which creates alternating regions of high and low pressure in the larynx. These waves, modified by traveling through the larynx, pharynx, and finally the oral cavity, propagate through the air. If you've studied acoustics, or even the waves part of introductory physics, this puzzler might have crossed your mind during a finals cram session: **If I were to scream long enough, could I heat up the cup of coffee in front of me?**

A silly question? Maybe. Sound Interesting? Definitely.

Where do we begin? With any Fermi problem (estimation problem), the first step is to restate the puzzle into a potentially answerable physics problem. For starters, what's the goal? We want to heat a cup of coffee... using sound waves. So, in essence, we're trying to see if there is enough energy in sound to heat the water in coffee within a measurable time frame.

(While this might seem like a silly exercise, this type of problem is exactly what many physicists are paid to do in the workforce. In industry, companies will hire physicists for their ability to take ill-formed, impossible to look up questions and answer the deepest question of all: Is it possible?)

There are many ways to approach this. First, let's declare some basic assumptions to a) help narrow the complexity of the problem and b) try and simplify the calculations to something manageable. This is really an energy problem, so first let's estimate how much energy it takes to heat a cup of coffee. From Intro Physics II, we might remember that the energy E_{cup} to heat water looks like:

$$E_{cup} = m \cdot C_{coffee} \cdot \Delta T,$$

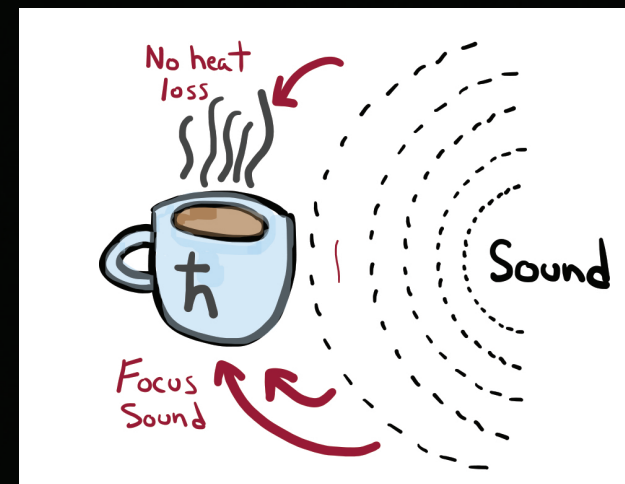


Figure 1. Here, we're assuming that the sound waves all go into the cup and no heat is lost, making the problem more manageable. Image by Brad Conrad.

where ΔT is the change in temperature of the coffee, m is the mass of coffee, and C_{coffee} is the thermal heat capacity of the coffee.

Let's assume that the thermal properties of coffee are the same as water. Given that coffee is almost entirely water, this is likely an accurate assumption. If anything, the organic material in the coffee has a lower thermal mass than water, since water has such a large value. So

$$C_{coffee} = C_{H_2O} = 4.186 \text{ kJ/g/K}.$$

Let's also assume that the coffee is cold from a long study session, about 20°C, and that we really want it around 90°C. And finally, we need to estimate the amount of coffee. A cup is about 8 oz., or about 240 mL. We can use that to get the mass of coffee since the density of water is about 1 kg per liter at standard temperature and pressure.

Taking everything together, we can calculate how much sound energy we'd need to make the coffee warm:

$$E_{cup} = m \cdot C_{coffee} \cdot \Delta T = (0.240 \text{ kg}) \cdot (4.186 \frac{\text{kJ}}{\text{kg}\cdot\text{K}}) \cdot 70 \text{ K} \cong 70 \text{ kJ}.$$

Now that we know the energy needed to warm the coffee, we need to consider how much energy a person's screaming could, in theory, impart to the coffee. From introductory physics we might

remember that we can calculate the power of sound per unit area, which is the sound intensity level, using the equation

$$L_I = 10 \cdot \log_{10} \left(\frac{I}{I_0} \right),$$

where I is the sound intensity in decibels (W/m^2) and I_0 is the reference sound intensity 10^{-12} W/m^2 . Therefore, the power delivered to the cup would be the sound intensity level times the area of the absorber. As a helpful hint, a loud, but not painful, scream is about 100 decibels.

Remember that the farther someone is from a sound, the quieter it is, since sound decreases as the inverse square of the distance. And, finally, the last assumption I'll give you is this: Let's assume that the cup is right in front of us, so the sound waves don't go anywhere except into the cup (Fig. 1).

What other assumptions do you need to make? Improving the diagram might be helpful. Then you're ready to tackle these three puzzlers.

Puzzler 1: How long would it take to warm up that coffee?

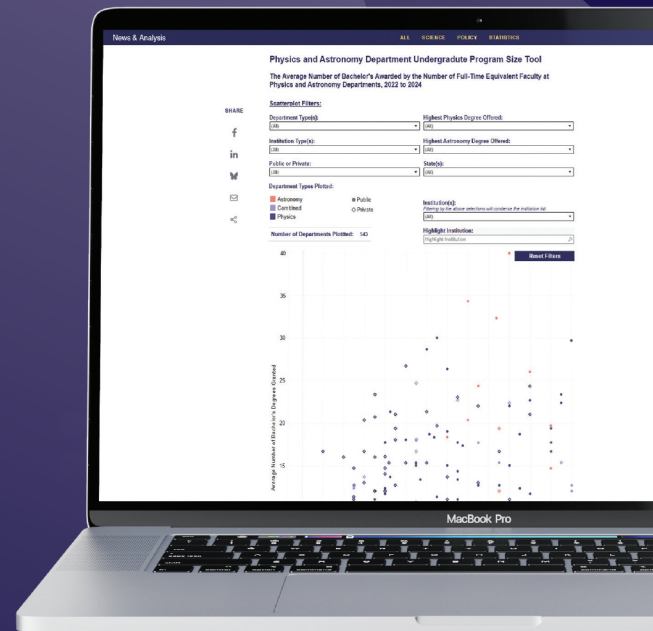
Puzzler 2: If you wanted it to be warm in an hour, how many people would you need to scream simultaneously?

Puzzler 3: Assuming that it would take a "long" time for one person to warm the cup, what other assumptions do we need to make? If we allowed black body radiation of the cup, how much longer would it take? //

"All of physics is either impossible or trivial. It is impossible until you understand it, and then it becomes trivial."

—Ernest Rutherford

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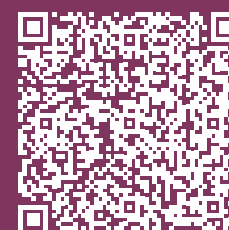
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Embry-Riddle Aeronautical University - Prescott

Damien Koon
Florida Institute of Technology

Khanh Vu
Mount Holyoke College

Lindsay Taylor
University of Utah

Madison Wilson
Berea College

Walker Law
Coe College

SPS AWARD FOR OUTSTANDING UNDERGRADUATE RESEARCH

These awards are made to individuals for outstanding research conducted as an undergraduate. Winners are awarded \$2,000 to present their research at an AIP Member Society meeting and receive \$500 for themselves and \$500 for their SPS chapter. Learn more at spsnational.org/awards/outstanding-undergraduate-research.

Angelina Zhang
Georgia Institute of Technology

Roshan Mehta
University of Rochester

2026 SPS SUMMER INTERNS

The SPS summer internship program offers 10-week positions for undergraduate physics and astronomy students in science research, education, outreach, and policy with organizations in the greater Washington, DC, area. Students are placed in organizations that use the interns’ skills to engage with the community and promote the advancement of physics and astronomy.

Amelie Heying
Hamilton College
History & Library Intern, American Institute of Physics (AIP)

Bailey Wolf
Embry-Riddle Aeronautical University - Prescott
Mather Policy Intern, National Institute of Standards and Technology (NIST)

Daniel Willson
Wichita State University
Careers Toolbox Intern, SPS

Ethan Raupers
University of Rochester
Policy Intern, NIST

Faith Simmons
East Tennessee State University
Science Writing Intern, Physics Today

Jahanvi Chamria
Colgate University
AI Guide Intern, Lawrence Livermore National Laboratory

Madelyn Stochaj
Rochester Institute of Technology
Science Outreach Catalyst Kit (SOCK) Intern, American Association of Physics Teachers and SPS

Michael Bo
University of Richmond
Mather Policy Intern, National Science Board



ABOVE: The 2026 SPS summer interns pose for a photo at orientation. Photo by SPS.

Nicole Everage
University of California, Los Angeles
Science Policy News Intern, AIP FYI

Nora Hicks
North Carolina State University
Program Assessment Intern, Department of Defense Office of Cost Assessment and Program Evaluation (CAPE)

Paige Nolan
University of Maryland, College Park
Research Intern, Space Telescope Science Institute

Sierra Focazio
Appalachian State University
Public Engagement Intern, American Physical Society

Thomas Qian
University of Rochester
Research Intern, US Geological Survey //

APPLY FOR SPS CHAPTER AWARDS!

Applications are due November 16
students.aip.org/awards

Future Faces of Physics Awards of up to \$600 support projects that promote physics and astronomy across cultures.

Marsh W. White Awards of up to \$600 support projects that promote interest in physics and astronomy.

SPS Chapter Research Awards of up to \$2,000 support imaginative chapter research activities likely to strengthen the chapter.

Sigma Pi Sigma Chapter Awards of up to \$600 support local or regional chapter inductions and events that build community or promote awareness of the honor society.

PHYSICS

Application due: January 15, 2027

Apply: <https://bit.ly/4bja2o3>

Degree(s): PhD

Fields offered include:

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biophysics, condensed matter, soft matter

Questions: physics@ucmerced.edu

- Average stipend per academic year: **\$38,000**
- University founded in **2005**
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PHYSICS

Application due: January 5, 2027

Apply: applyto.graduateschool.vt.edu

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Fields offered include:

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No GRE Required

Questions: gradphys@vt.edu

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Quantum Information Science

Questions: salsbufr@wfu.edu

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