

A physics master's degree opens doors to myriad careers

If you want to improve your options in industry or consider a career in teaching, a master's in physics may be for you.

In the US—unlike in many other countries—academics in physics and some other fields commonly treat the master's degree as an ugly stepchild. At PhD-granting institutions, leaving with a physics master's degree may even be accompanied by undertones of failure. So is a master's degree in physics a consolation prize or an aspirational degree?

For many people, a master's is a step toward earning a PhD. And in society at large, and among employers, a physics master's degree is a respected qualification that can lead to interesting, well-paying careers in industry, government, education, and not-for-profit sectors.

Physics master's programs vary widely in what they offer and require, whom they attract, what their graduates go on to do, what tuition they charge, and what financial support they provide. Despite those differences, they all share a sense of purpose. As David Kieda, an astronomer and dean of the graduate school at the University of Utah, says, "Our job is not to make the students bend to our experiences, but to bend to the needs of our students."

Alternative career paths

Over the past few years, California State University Long Beach (CSULB) has consistently conferred among the most physics master's degrees of any institution in the country, with 15–20 a year, up from just 3–5 annually a decade or so ago. The three main career paths for master's recipients are teaching, industry, or the PhD, says CSULB physicist Andreas Bill. A master's is the highest physics degree available at the school.

Master's programs variously require students to do a project, thesis, or internship, or to pass comprehensive exams. Challenging and interesting jobs in

industry increasingly demand more knowledge than a bachelor's recipient typically has. For many industry positions nowadays, says Bill, "new hires need to know quantum mechanics and statistical physics." At CSULB, he says, "students learn graduate physics and techniques that are useful in industry—maybe they write code to solve a theoretical problem or learn to make thin films or to use a scanning electron microscope." Students gain confidence from struggling with and solving real-world research problems, he adds.

Programs attract students who are unprepared for the PhD or are unsure that's what they want to do, according to Bill and others. For some, the PhD seems like too long a commitment. "The master's can be a path for students in difficult socioeconomic conditions and underrepresented minorities," Bill says. "It's an important channel to increase diversity among highly educated persons."

Some choose to pursue a master's first because "they woke up late," says Bill. "They realize they want to do a PhD, but their grade point average is low." Or as Jeff Wilkes, who runs a master's program in physics at the University of Washington, Seattle, puts it, "students who want to do a master's often say, 'I drank too much beer, and now I realize I should have paid more attention.' They drifted through college and now are stuck in a boring job." It's easier to gain admission into a master's program than a PhD program; some schools accept students with less-than-stellar grade point averages, contingent on performance. The master's gives them a chance to earn better grades and see if they like research. "We catch some excellent students that way," Bill says.

About half of CSULB physics mas-



ter's recipients continue to the PhD, Bill says. Each year a few enter through the American Physical Society (APS) Bridge Program, which aims to help students from underrepresented groups get their physics PhDs (see the article by Ted Hodapp and Kathryn Woodle in *PHYSICS TODAY*, February 2017, page 50). A year after receiving their exiting physics master's degree at a master's- or PhD-granting department, 30% of US students and 50% of international students from the combined classes of 2014, 2015, and 2016 were enrolled in a physics PhD program at a different institution, according to the Statistical Research Center at the American Institute of Physics (AIP; publisher of *PHYSICS TODAY*). The rest were in other graduate programs (9% of citizens and 15% of noncitizens), had left the country (4% and 17%), had entered the workforce (50% and 14%), or were unemployed (7% and 4%).



AFTER EARNING HER MASTER'S DEGREE IN ENGINEERING PHYSICS last year at Appalachian State University in Boone, North Carolina, Mariah Birchard took a job working on instrumentation and automation of telescopes at Gemini South in Chile.

Jesús Pando, who heads the physics master's program at DePaul University in Chicago, says that students "who are ready for and can get accepted to a PhD institution should always do that," especially if they plan to continue to the PhD. "They will get the lay of the land and form support systems with other students—everything that is necessary but is not strictly academics." But, he says, for students who want a more personalized experience, a master's-focused institution can be a good fit.

Changing life paths

Some master's programs in physics cater to particular needs. Since the 1980s Harold Metcalf has run a small program at Stony Brook University that special-

izes in scientific instrumentation. "There are students who struggle with math or concepts, but they are golden in the lab, they are so good with their hands. Those are the kids for whom this program is designed," he says. Students take courses at the undergraduate and graduate levels and complete two hands-on projects. Typically about five people are enrolled at any given time; graduates have gone on to work on telescopes, music synthesizers, the Brookhaven accelerator test facility, and other things. "I view this as a professional degree, which confers on the students the notion that they are physicists," Metcalf says.

The physics master's degree offered by the University of Washington was started in the 1970s with local compa-

nies, Boeing in particular, in mind. By taking a master's degree, employees could further their education and potentially gain a promotion. The program remains evenings and online only, but the student base has widened to include high school teachers, military personnel, employees at a broad range of companies, and some fresh bachelor's recipients, says Wilkes. About 15 people enter each year, and about 60 are enrolled at any given time. "This program is intended to help people change their life path," he says. Students take courses and do a research project.

Originally, notes Wilkes, the Washington program was supported by the state. But about 10 years ago it was forced to become self-sustaining. Students pay about \$26,000 to complete the degree. Sometimes businesses foot the bill to train their employees. Stony Brook students also pay tuition, but many run undergraduate physics labs to help cover costs. At CSULB and other schools where the master's is the highest degree available, students may work as teaching assistants.

As with many programs, the master's in physics at the University of Massachusetts Dartmouth feeds into local industry. "Graduates are snapped up by defense contractors," says Gaurav Khanna, the gravitational physicist who runs the program. "If you want to go into industry or teaching, a master's is a good degree," says Gary Forrester, who earned his master's in the program in 2012. "It's pretty applicable in most technical fields."

Forrester began a PhD with Khanna, but was increasingly drawn to teaching. One Thursday in 2014, he responded to an ad for a high school teacher, and by the following Monday he was in the classroom. Forrester says his physics background makes him a better teacher. "Every day kids ask me, What happens at the edge of a black hole? What was the Big Bang? They ask about quantum mechanics. Because of my background, I can tell them about cutting-edge research."

Professional degrees

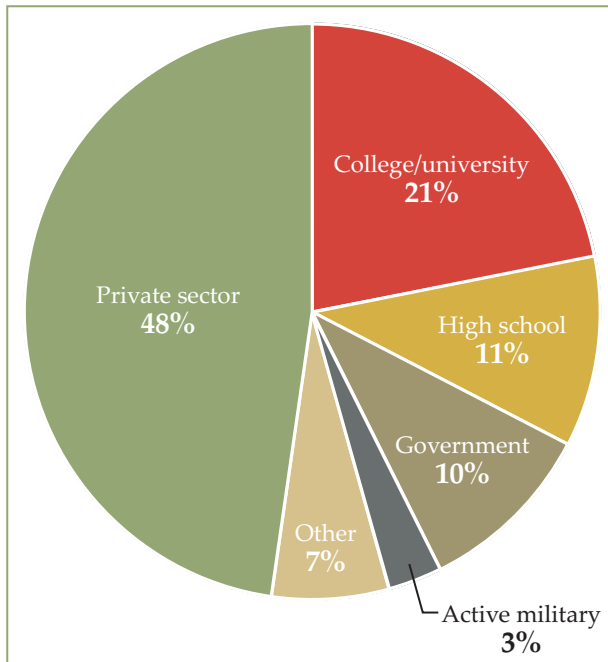
In the 1990s a dip in openings for academic positions led many students and early-career scientists to leave the sciences.

It also led to the Alfred P. Sloan Foundation's initiative to create professional science master's (PSM) degree programs. "We talked to employers in technical fields that were heavily dependent on science and technology for their businesses, and we found a strong interest in hiring people at the master's level," recalls Michael Teitelbaum, a founding director of the Sloan initiative. In addition to graduate-level science experience, employers wanted hires to come in with understanding and skills in business, marketing, project management, communications, and teamwork.

Sloan started by seeding a few master's programs at PhD-granting universities. The programs combined science with business skills. The PSM degrees were not seen as "a stepping stone or a consolation," says Teitelbaum, but as a route to science-intensive careers outside academe. "People were smart enough to get a degree in physics, but they didn't like the academic career prospects," he says. "We thought it was a shame if they felt they had to leave science. Would they be interested in a science master's degree that prepared them for industry? The answer turned out to be yes."

The National Professional Science Master's Association, launched in 2005, grew out of the Sloan initiative. Programs that meet qualifications including coursework, internship requirements, and industry advisers can join. Some 345 programs at 157 institutions—including a handful in Australia, South Korea, and the UK—are among its members. The programs span many sciences and specializations, from agriculture to nanoscience.

Rice University offers PSM degrees in subsurface geoscience, space studies, environmental analysis, and bioscience and health policy. "When we recruit," says Rice PSM program director Dagmar Beck, "we target students who love science,



A YEAR AFTER EARNING AN EXITING MASTER'S DEGREE in the US, some 39% of recipients from the combined classes of 2014, 2015, and 2016 were in the workforce. The chart shows the sectors of employment. Of the remaining recipients, 6% were unemployed, 8% had left the country, and 47% were pursuing higher degrees. (Data courtesy of the Statistical Research Center at the American Institute of Physics.)

but don't want to go into a lab and do research." Many people study science as undergraduates and work in jobs where they never use their science skills again, she says. Graduates from the Rice PSM program work, for example, in the aviation and petroleum industries and for environmental, medical, and governmental organizations.

A PSM program's contacts with industry strongly influence the curriculum and create networks for the students to find internships and jobs. On the advice of industrial board members, Rice's geosciences program, for example, is introducing a class on shale, fracking, and other new technologies. And a couple of years ago, the university's environmental PSM faculty began teaching students

to write sustainability reports and create environmental impact statements.

Potential employers often look for engineers, says David Garrison, founding chair of the physics master's program at the University of Houston–Clear Lake, which participates in the APS Bridge Program and offers a PSM degree in technical management. "Physics is a more unknown quantity, so we have been working with local industry. Once they realize that physicists are trained to solve a huge range of problems, they love them," he says.

Case Western Reserve University offers a PSM in physics for entrepreneurship. The program straddles physics, law, and business, says director Ed

Caner. "Our students have a mindset that they want to be an entrepreneur or to work for a small company." One student went to work for a company that does optical coating. The graduate focused on minimizing the losses in batch processing. "He looked at things from a sales standpoint and from a physics standpoint. That is where our students shine." Full tuition is about \$60,000. It's a challenge attracting students because many already have debt, Caner notes. But he says most graduates are able to pay off their master's loans in a few years.

"Underserving our community"

People with a master's degree in physics go into a range of fields (see figure); in the private-sector category, jobs include staff scientist, software developer, project manager, and various engineering-related titles. According to data from AIP's Statistical Research Center, the combined master's degree classes of 2015 and 2016 saw typical private-sector starting salaries of \$52,000–\$76,000. Physics bachelors started with salaries of \$45,000–\$75,000 in private-sector science, technology, engineering, and mathematics jobs,



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JEFF BARGIEL, a graduate of Case Western Reserve University's professional master's in physics entrepreneurship is back with other alumni to tell current students about their startups. His involves nontoxic herbicides.

and holders of a physics PhD earned initial salaries of \$85,000–\$118,000.

Even if every physicist wanted to become a professor, the jobs aren't there. Hard numbers are not available, but based on combined data from NSF and AIP, in 2013 roughly a third of physicists held tenure or tenure-track positions 10–14 years after earning their PhD. So promoting and valuing viable career alternatives might seem obvious. Still, in university settings it can be difficult to get buy-in from faculty for master's programs. Faculty members who are focused on research and producing intellectual heirs "and the next Nobel Prize winner" don't see why they should spend time on master's students, says Teitelbaum. "Master's education is more labor-intensive for teachers." That's one reason that the PSMs have flourished at institutions where the master's is the highest degree in the field, he adds. And people involved in master's programs say it's best to have at least one faculty member who has a strong commitment to the program.

Mentoring master's students is a challenge, says DePaul's Pando. "You spend a lot of time bringing them to a level that is acceptable, and right when they get

there, they leave. It's rewarding to see them succeed, but I don't get much of a return in terms of my own research agenda."

At PhD-granting institutions, the motivation to mentor master's students is also lowered by the incentive structure for faculty: Universities tend to reward faculty more for graduating PhDs than masters, and many states provide more funding to public universities per PhD graduated than per master's degree produced. "It's a tension," says physicist Geoff Potvin of Florida International University.

"We are underserving our community by not preparing students for the host of things they will do with their careers," continues Potvin. "It's a cultural blind spot." A master's can help people become saleable. They are more qualified than bachelor's recipients. And they can be perceived as more attractive than PhDs, who sometimes want to pursue their own research or may lack experience in teamwork, communications, business, and the like. Says Potvin, "The advanced preparation in math, problem solving, and programming that master's students receive is highly valued by many employers outside of physics."

Toni Feder



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