

Training Physicists for Industry

For physicists, jobs in industry outnumber those in academia. As a consequence, and frequently as a preference, those with bachelor's degrees often seek an alternative to the physics Ph.D., some in a different discipline. In response to this, some universities have created professional master's degree (PMD) programs to provide physics graduates with the broader range of

ent and usually terminal degrees that combine much of the fundamental knowledge of a traditional physics master's degree with specialized skills applicable to industry. The success of such programs requires solid departmental support. "You have to have a group of faculty who are committed to the idea because it involves curriculum development," says Roman Czujko, director of AIP's Statistical Research Center and a co-author of its PMD report.

PMD programs differ widely in their structures and areas of specialization. When Alabama Agricultural and Mechanical University realized that none of Alabama's schools offered either optics or materials science, its physics department created a PMD in optics and lasers and materials science. Some schools have formal internship programs; others have informal work agreements with local employers; some do everything on campus. Columbia University provides no financial assistance to students in its medical physics program, whereas Northern Illinois University tries to arrange a teaching assistantship for each of its incoming PMD students.

Successful programs

PMDs are market-driven programs and are not unique to physics. "If you think about executive master's degrees, they are designed to accommodate the needs of their customers," says Philip W. Hammer, vice president of the Franklin Institute in Philadelphia and a co-author of the AIP report.

Hammer and his colleagues identified nine features that contribute to the success of a PMD program:

- an external advisory committee composed of members from local and regional industries and research laboratories whose work is relevant to the program

and who have a stake in its success,

- actively networking and promoting interactions with industry,
- exploiting faculty specialization to design courses applicable to industrial careers,
- an approach that requires students to take courses in other relevant departments,
- research ties related to the focus of a school's program, which may be done in partnership with industry,
- internships and other partnerships—such as allowing employed students to tailor their training to their companies' needs—that help students develop the skills needed by industry,
- hands-on experience through appropriately designed laboratory work,
- flexible class schedules that enable students to take courses in the day or evening, and
- encouraging the development of communication and team skills important to working in industry.

The AIP study, supported by the Alfred P. Sloan Foundation, categorized the 62 PMD programs it identified as strongest, strong, and new. The ratings, however, provide only a measure of the programs' productivity—their numbers of graduates—and do not indicate the quality of the education they provide.

No PMD program incorporated all of the nine features of success, but most of the strongest programs included many and awarded a minimum of four degrees a year to students, most of whom accepted jobs in industry. The 17 strong programs also incorporated many of the characteristics of success but awarded fewer than four degrees annually. "These may look like small numbers, but for physics departments they are quite reasonable," Hammer says. The 23 new programs had not yet admitted their first students or were too new to assess.

The most important characteristic of a successful program is that it seeks outside input and close relations with industry—such as the use of an external advisory committee. "We get advice from people who are going to hire our students," says Martin Buoncristiani, chair of the department of



Texas Tech University

Figure 1. Ric Justus, an M.S. student shown here examining the results of a plasma deposition with Texas Tech physics professor Roger Lichti, interned at Intel and later went to work for the company.

technical experience and expertise sought by companies. A 2001 report by the American Institute of Physics (AIP) found that 62 of the nation's physics departments offered master's degree programs aimed at preparing students for industrial careers, and that number has since grown by at least 4.

"What you are looking for when hiring someone fresh out of a university is the learning capability," says Joe Lebowitz, director of yield and product engineering at Texas Instruments' Kilby Facility (Dallas, TX). "With the professional degree, students get the theory but they get a little more of a slant toward practical application, and that is valuable. I have more confidence in their ability to become productive faster."

By definition, PMDs are employment-ori-

physics, computer sciences, and engineering at Christopher Newport University (CNU) in Newport News, Virginia. “Often-times, when we bring proposals to the advisory committee, members point out ways that we can improve the program that we would never have thought of without their input.”

Strengthening ties with industry may include consulting agreements, internship programs, periodic visits to companies, and inviting industrial scientists and managers to campus. Physicists at Texas Tech University in Lubbock visit students during their internships and talk to people in the companies where they work. “We try to do that early to find out how things are going and to ensure that the project is on track, and then later to make sure the students are making progress,” says Mark Holtz, professor of physics and director of the program. “That gives us good visibility with the companies.”

Finally, students need learning experiences such as internships or laboratory projects. “The value of the professional master’s degree comes from the networking and problem-solving experience that accompanies working in areas important to industry,” Hammer says. An added value for students and companies is the ability to hire qualified employees locally. “When students graduate, they usually look for work in the local area. This way I don’t have to spend money on relocating somebody,” says Charles Noll, who has hired PMD graduates to work for a National Aeronautics and Space Administration (NASA) contractor.

The five university programs that follow illustrate different features and activities that make up the PMD movement.

Oregon

The University of Oregon’s master’s in applied physics attracts students seeking employment in industry or other professional careers. “We started this degree because we perceived that there was something missing between the bachelor’s degree and the Ph.D., which the traditional master’s did not really serve,” says physics chair Dietrich Belitz. “We had the impression that there was definitely a market for a degree that was more focused on technical experience and less on preparing people to do academic research. It is working out very well.”

Oregon’s program requires an internship, typically of three to six months’ duration, which appealed to Laura Schreiner, a 2000 graduate of the program. “In the traditional physics master’s, you don’t get much work-related experience or come out with company connections,” says Schreiner, who is now a photolithography process engineer with Hynix Semiconductor Manufacturing America (Eugene, OR), the company where she did her internship.

The Oregon program, a joint venture between the physics department and the university’s Materials Science Institute, draws faculty from the physics and chemistry departments. Six students are enrolled, and 29 have graduated from the program. “Our strongest point is the overlap and close collaboration between physicists and chemists

so that students are really exposed to both disciplines,” says Belitz. “When they go to work in industry, hopefully they will have an easier time relating to people with different backgrounds.”

Texas Tech

In its program, Texas Tech emphasizes laboratory experience on campus and requires an off-campus internship, which means students must move. Without a significant industry presence in Lubbock, students do their internships elsewhere in Texas or in New Mexico or California, at companies such as Texas Instruments.

“We have one year of course work aimed at preparing students to work in the semiconductor industry,” Holtz says. The program foregoes some of the courses of a traditional physics master’s, such as quantum mechanics, electrodynamics, and statistical mechanics, and focuses on general microelectronics and parametric-testing courses.

“A critical course is advanced process, which students take in the second semester and is required before they go out on an internship,” says Holtz. “In that course, they go through many of the processing steps for making an integrated circuit, and they make a simple photodiode and a simple metal-oxide-semiconductor capacitor. When they have done that, we feel they understand what goes on inside a fabricating plant.” The Texas Tech PMD program currently has 10 students (Figure 1).

Northern Illinois

Northern Illinois University (NIU) in DeKalb played to its strengths in shaping its PMD program. Many physics faculty have research affiliations with Fermi National Accelerator Laboratory (Fermilab) and Argonne National Laboratory. “So we send the students there for the summer, or they might work with one of us on a special project,” says Susan Mini, associate professor of physics and the department’s graduate curriculum chairperson.

Students have a choice between a specialization in high-energy physics and synchrotron radiation. At Fermilab, students

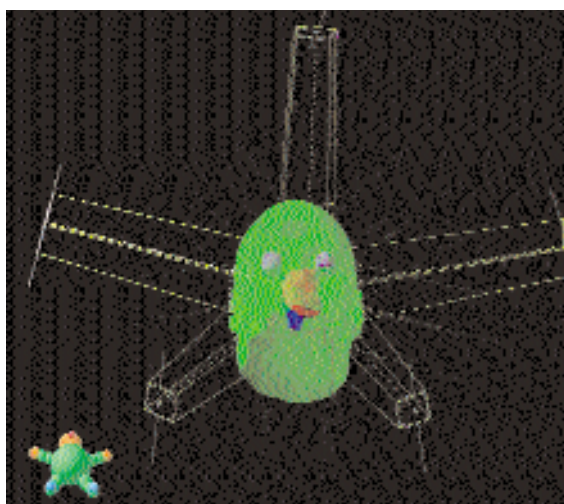


Figure 2. Three-dimensional display of a multifield conformal radiation therapy plan on a reconstructed image of the brain, used for students in the medical physics practicum.

do predominantly elementary-particle or accelerator physics. At Argonne, the focus is on materials science. Moreover, NIU houses the new Northern Illinois Center for Accelerator and Detector Development, where students work with faculty in developing new technology for Fermilab.

Today, the department has 25 students in its traditional master’s degree program and 15 seeking a PMD, which typically takes two years beyond a bachelor’s degree.

Columbia

Students in the medical physics program at Columbia University study with faculty members in the department of applied physics and applied mathematics and at its medical school. In addition to course work, students engage in one or more practica—research projects in a medical setting that do not involve direct contact with patients. Most graduates go to work at hospitals in the New York City area (Figure 2).

The program limits the number of students it admits to ensure quality and to avoid overstocking the market. “It is a one-year program, and the students make very good money when they come out,” says professor of physics Thomas C. Marshall, the program director.

Many of the students enter the program while working at medical facilities, and many keep their jobs while pursuing their degree part-time. Michael Worman held a bachelor’s degree in physics, but when he enrolled in the medical physics program, he

was working as a computer programmer, a job he continued for 30 months until he graduated. “We studied a wide range of medical physics,” says Worman, who now works at Memorial Sloan-Kettering Cancer Center (New York, NY). “It was a good introduction to the field, and it introduced me to the people where I now work.” One of his practica involved a study whose findings will be published with Worman as a co-author.

Christopher Newport

Set in the midst of an area that includes the Thomas Jefferson Accelerator Facility and NASA’s Langley Research Center, CNU created a PMD program with flexible hours that caters to workers employed locally. Students can choose from four areas of specialization: modeling and simulation, solid-state systems, advanced computer systems and instrumentation, and computer science. The program, which currently has 15 students, makes use of faculty from all components of the department of physics, computer science, and engineering.

“One strong point is the interdisciplinary character of the program,” says Buoncristiani. “We make a direct effort to include three things in a student’s experience: communication skills, working in teams, and a project, which teaches them that in the real world, you generally live with problems for a long time.” Although the program has no formal internship requirement, students often spend time working on projects and getting to know staff at places such as the Jefferson Laboratory.

Now CNU is developing a five-year PMD program in which students earn a bachelor’s degree in physics in four years and receive their master’s after one additional year. “We feel it will fill a need for both students and industry,” Buoncristiani says.

Further reading

Norton, S. D.; Hammer, P. W.; Czujko, R. *Mastering Physics for Non-Academic Careers*, American Institute of Physics: College Park, MD, 2001; 50 pp.; available at <http://www.aip.org/professionalmasters>. 