Training PhD Physicists for Industrial Careers: The Industrial Leadership in Physics Program at Georgetown University.

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The Industrial Leadership in Physics program

- A novel graduate program, started in 2001, providing an innovative approach to preparing PhD physicists for hi-tech industry.
- Graduate level curriculum in advanced applied physics.
- Training in business management and entrepreneurship.

Overview

- Motivation & history
- Program overview
- Curriculum
- Integrative experiences
- Industrial apprenticeships
- Results
- Advisory committee
- Summary

Motivation

- The Committee on Science, Engineering, and Public Policy, a committee of the National Research Council, issued a report entitled *Reshaping the Graduate Education of Scientists and Engineers*.
- The National Science Foundation held a workshop in 1995 on “Graduate Education and Postdoctoral Training in the Mathematical and Physical Sciences” that recommended closer academic/industry connections for graduate students.
- The Industrial Research Institute, a non-profit organization whose members include over 285 leading companies issued a report entitled *Enhancing industry-university cooperative agreements*.

Motivation

These reports recommended:

- graduate programs should respond to the needs of industry - less specialization, more broadening of the educational experience of the students.
- enhancing of students' awareness of the unique requirements of the industrial environment (developing communication skills, the ability to work in cross-cultural teams with short deadlines, providing an understanding of the business environment, entrepreneurial initiative).
- students should be taught to appreciate applied research problems in an industrial setting.
- students should spend time off campus in industrial internships.
- strengthening of the interactions between universities and industry, including the creation of exchange programs.

Departmental history – GU Physics

- Original (standard) graduate program suspended in mid-80's (retiring faculty)
- Nearly complete turnover in faculty in mid to late 90's
- 13 regular faculty, focus on condensed matter/materials, device, bio-physics
- Restarted graduate program in 2001 with focus on industrial physics

Program overview

- Physics + business coursework (three semesters plus one summer)
- Business courses: “Gateway to business”, accounting and marketing or finance, entrepreneurship capstone (MBA program)
- “Industrial problems in physics” and “Intellectual property” courses
- Integrative experiences
- Comprehensive and Qualifying exams
- Industrial apprenticeships

Degree options

Typical PhD program:

- 22 credits in physics courses
- 12 credits in business/industry oriented courses
- Industrial apprenticeship
- Thesis research

Typical MS program:

- 22 credits in physics courses
- 12 credits business/industry oriented courses
- Thesis or additional coursework options

Key features of the ILP program

- Modular format to allow vertical and horizontal integration, significant team projects, and adaptability to the needs of our students.
- Coursework in the McDonough School of Business at Georgetown University
- Year-long apprenticeship with an industrial partner.

Curriculum

- Modular (half semester) format
- Applied physics curriculum (focus on CMP) plus business courses
- Three semesters plus one summer of coursework

Curriculum

Modules in Quantum Mechanics (2), Condensed Matter Physics(3) , Statistical Physics, E&M and also:

- Sensors and sensing
- Digital electronics
- Computational physics (2)
- Advanced Characterization Methods
- Soft matter

Curriculum

- Gateway to business course (overview of business)
- Industrial problems in physics (taught by visiting industrial physicist – previously – Tom Clinton, Seagate; currently Dr. James Lavine, Kodak).
- Intellectual property (short course taught by patent attorney – John Ongman)
- Entrepreneurship course (in MBA program)

Integrative experiences

- One week group project after each module
- Aims to bring together topics from individual courses
- Industrial setting/role playing

Integrative experience

Examples:

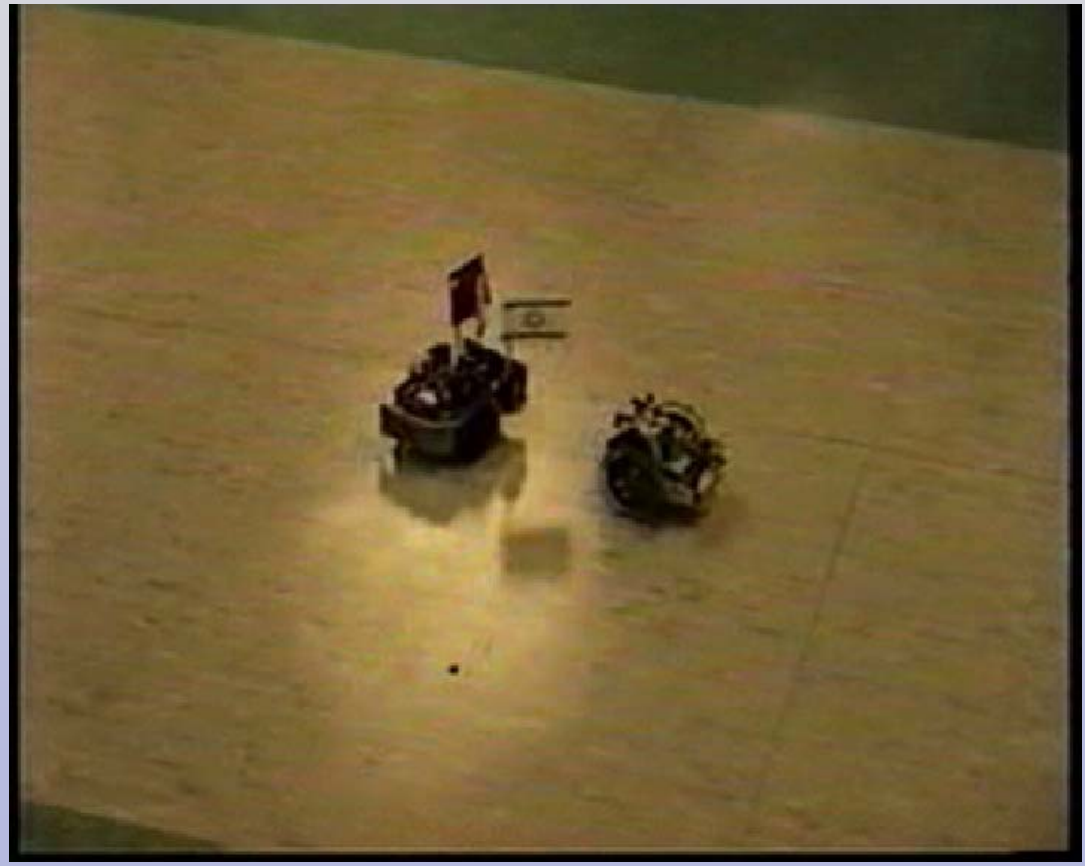
- Optical Filter

Students take an existing prototype thin film optical filter (4Wave Inc.) and reverse engineer it, combining measurements of the spectrum with computational models of the transmission

Integrative experience

Robotics:

Students design and program BOE Bots to accomplish specific tasks. In this movie, one robot had to follow without hitting the second, which was programmed to try to escape or cause a collision.



Industrial apprenticeships

- ~12-month apprenticeship in industry, working with an industrial mentor.
- Integrated into Ph.D. thesis research.
- Funding from the industrial partner is used to support the costs of training the students.
- Students benefit from experiencing the industrial environment firsthand.

Industrial apprenticeships

Typical contract

- Georgetown faculty member and industrial partner work out specific project
- Industry partner retains full IP
- Industrial partner pays flat fee, which covers student stipend, tuition, health insurance, relocation expenses, etc.
- Student remains enrolled for off-site thesis research
- Student signs off on contract with GU stipulating overall parameters of work

Industrial apprenticeships

- List of industrial partners
  - IBM (5)
  - Seagate (4)
  - ITT Industries
  - SAIC
  - Luna
  - JHU Applied Physics Lab
  - NIST
  - Naval Research Lab
  - Arete Associates
  - Proctor and Gamble
  - Infinite Biomedical
  - Protiveris
  - OADS
  - Army Research Lab
  - APL/Lockheed Martin
  - NASDAQ
  - Air Force Research Lab/Optimetrix

Industrial apprenticeship examples

- Luna Innovations Inc.

Russel Ross

Russ spent a year working at Luna Innovations Nanoworks in Danville, VA. His apprenticeship work involved development of Luna's TRIMETASPHERE® carbon nanomaterials for organic photovoltaics. Luna has continued to support Russ' PhD thesis work, which he will complete this spring

Industrial apprenticeship examples

- Seagate

Jianyun Zhou

Jianyun did her apprenticeship in Seagate Research Center in Pittsburgh, PA, in the Litho group, focusing mainly on electron beam lithography. Her project involved both simulations and experiments searching for an optimized design of the hard disk writing head. She was able to obtain very good high aspect ratio structures for the writing head.

Industrial apprenticeship examples

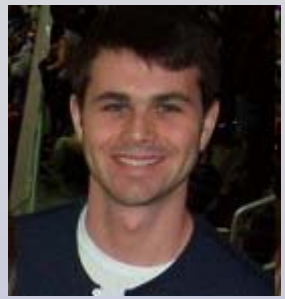
- IBM

Simon Hale

Simon Hale spent one year at IBM's Almaden Research Center, in San Jose, California on problems related to increasing the density of storage on magnetic tapes for archival storage. Simon's work involved writing a user-friendly computer code to calculate switching properties of bits of data on tape. Focusing on cases when the physical size of the bit is made very small and one needs to worry about effects of temperature, the shape of the grains, and the properties of the read/write magnetic field.

Industrial apprenticeship examples

- Naval Research Lab



Michael Helle

Mike spent a year working in the Plasma Physics Division working on several projects. The first project involved developing a computer code to model the propagation of intense laser pulses in water for NRL's remote underwater acoustic source program. Mike also experimentally investigated the plasma density of an air-plasma filament. Mike is staying at NRL for his Ph.D. thesis research, focusing on investigating the effects of externally injecting an electron beam into a laser wakefield acceleration structure.

Graduates of the program

- Three Ph.D. (one industry, one post-doc, one temp position APL).
- Seven M.S. – one teaching, two in finance, one entrepreneur, one consultant, one industry, one research scientist.

Advisory committee

The Advisory Committee is a standing committee of volunteers who provide advice and expertise for the operation of the Industrial Leadership in Physics (ILP) program.

- Bill Lewis (Prospect Technologies)
- John Ongman (Axinn Veltrop & Harkrider LLP)
- Barbara Jones (IBM)
- Bill Graver (Science Applications International Corporation)
- Tom Clinton (Seagate)
- Tom Schneider (ITT Industries)
- Robert Osiander (Johns Hopkins University/Applied Physics Laboratory)
- Brian Jamieson (SB Microsystems)

Challenges

- What do students really need to learn for a Physics PhD?
- Does industrial focus shift emphasis away from basic physics?
- Lack of student preparation.
- Recruiting.
- Interaction with business school
- Duration of apprenticeships – time away from PhD research.
- Making sure apprenticeship has pedagogical value.
- Work involved generating industrial contacts and contracts.

Successes

- Individual student successes
- Continuation funding from companies
- Interactions with Industry and B-school
- Work experience and networking for students
- Application of knowledge
- “dead time” right after comprehensives replaced with high pressure challenge

Conclusions

- There remains a need for graduate level training to specifically prepare students for industrial careers.
- Developing this type of program requires a significant amount of effort and buy-in from faculty and administration.
- The ILP is a successful alternative PhD program for students intending to go on to work in industry.

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