An Educational Initiative:

VIII-B in Review

by Thomas J. Greytak

In 2000, the Department created a new undergraduate program leading to the Bachelor of Science in Physics. The purpose of the program, named VIII-B, was twofold: to arrest the declining enrollment in physics, and to offer a less constrained option for those who enjoyed physics but planned to use it as a foundation for other career paths. VIII-B has now been available to three graduating classes. This is a good time to review how it came about, what it entails, and how successful it has been in meeting its goals.

AS THE LAST CENTURY CAME TO A CLOSE, while others were concerned about Y2K, the Department was alarmed by the decreasing number of S.B. degrees in physics. The decrease was part of a nationwide trend, but the decline at MIT was more rapid than the average. During the 1980s, the number of S.B. degrees in physics at MIT had remained relatively constant at about 70. During the 1990s, however, the number of degrees decreased steadily, reaching a record low of 35 in 2000.

We believed that the existing program provided our students with an unsurpassed preparation for graduate study in physics. However, upon reflection we realized that many students who were strongly attracted to physics had broader interests and would pursue other careers after graduation. For these students our required advanced undergraduate subjects left little opportunity, and no incentive, to explore other areas. While examining the situation at other universities we learned that, contrary to the national trend, the number of undergraduate physics degrees at Harvard had been increasing and was then at about 50. The physics curriculum at Harvard had fewer specific requirements than ours. Approximately half of Harvard's physics majors went on to medical, law, or business school, or were pursuing other non-physics careers. At MIT that fraction was only about a quarter.

With these ideas in mind we set about designing a new program. It was a department wide effort involving the Education Committee, the Physics Council, and open meetings with both the students and the faculty. The final version was approved unanimously by the physics faculty. The VIII-B program became official at an Institute faculty meeting in April of 2000.

Both the VIII and VIII-B programs lead to the same degree, a Bachelor of Science in Physics. VIII-B requires fewer specific upper level subjects in physics. They are replaced by a student-designed three-subject "focus group" that builds on the earlier foundation subjects in physics. The subjects in the focus group are not restricted to physics but in general are chosen to prepare the student for a particular, though not necessarily traditional, career path. Each VIII-B student's focus group must be approved by the Associate Department Head for Education. There are two other differences between VIII and VIII-B: VIII-B only requires one term of laboratory work while VIII requires two, and VIII-B does not require a senior thesis. Our goal was to make VIII-B as flexible as possible so that students can design a major that best fits their career goals in a changing technological world. Nevertheless, the degree is demanding: the number of required subjects

MIRANDA PRIEBE *graduated this year with S.B. degrees in Physics and Political Science. Her VIII-B focus was in science policy and she worked in this area during several summers. She explains, "I spent my first summer in D.C. working in Senator Carl Levin's office. I was working on defense issues and alternative fuel vehicle legislation. My boss had me focus on writing short explanations of technical issues relating to this legislation. The second summer, I worked at a think tank called the Center for Defense Information where I wrote an article about the technical hurdles facing the Airborne Laser. Next year, I am going to work at RAND on national security issues. I could never have fit in a political science degree without VIII-B and I think both have been really important to my career path. Going through the entire political science program rather than just doing a minor gave me a lot more perspective."*

TABLE 1
Requirements for the S.B. Degree in Physics Beyond the General Institute Requirements

VIII

Required Subjects

8.03	Physics III (vibrations and waves)
18.03 or	
18.034	Differential Equations
8.033	Relativity
8.04	Quantum Mechanics I
8.044	Statistical Physics I
8.05	Quantum Mechanics II
8.06	Quantum Mechanics III
8.13	Experimental Physics I
8.14	Experimental Physics II
8.ThU	Thesis (12 units)

Restricted Electives

One math subject beyond 18.03

Two additional physics subjects, including one of the following:

8.07	Electromagnetism II
8.08	Statistical Physics II
8.09	Classical Mechanics II

VIII-B

Required Subjects

8.03	Physics III (vibrations and waves)
18.03 or	
18.034	Differential Equations
8.04	Quantum Mechanics I
8.044	Statistical Physics I
	One of the following subjects:
8.05	Quantum Mechanics II, *or*
8.033	Relativity, *or*
8.20	Introduction to Special Relativity
	One of the following experimental experiences:
8.13	Experimental Physics I, *or*
	a lab subject of similar intensity in another department, *or*
	an experimental research project/senior thesis, *or*
	an experimentally oriented summer externship

Restricted Electives

One additional physics subject

Three-subject focus group approved by Department

in the sciences (including math), 17, is greater than the number of required subjects in the same category, 15, for the honors degree at Harvard. The specific requirements for VIII and VIII-B are listed in *Table 1*.

The new VIII-B program was popular with the students from the start. We found that rather than using VIII-B to lighten their academic loads, students were constructing rigorous programs in a particular area that appealed to them. Table 2 is a partial list of focus areas that have been used so far. In some areas, such as cosmology or field theory, most of the subjects comprising the focus will be in the physics department. In other areas, such as electronic materials or planetary atmospheres, there is a natural overlap with another department's offerings. Students particularly appreciate the ability to use subjects from different departments, or even other universities, to achieve their goals.

A student interested in nanotechnology used INTRODUCTION TO SOLID STATE PHYSICS from Physics, along with MICROELECTRONICS PROCESSING TECHNOLOGY and SUBMICROMETER & NANOMETER TECHNOLOGY from Electrical Engineering and Computer Sciences (EECS).

A student with an interest in fluid dynamics built his focus from ADVANCED PARTIAL DIFFERENTIAL EQUATIONS WITH APPLICATIONS in Math, ANALYSIS OF TRANSPORT PHENOMENA in Chemical Engineering, and FLIGHT VEHICLE AERODYNAMICS in Aeronautics and Astronautics; all are graduate subjects.

A woman with a focus on science in Russia took EINSTEIN, OPPENHEIMER, FEYNMAN: PHYSICS IN THE 20TH CENTURY and SOVIET POLITICS AND SOCIETY 1917–1991 at MIT, and a Slavic language course at Harvard.

A fellow planning to teach high school science put together a focus program from subjects at three different universities: CHEMICAL ENGINEERING THERMODYNAMICS at MIT, UNDERSTANDING AND IMPROVING SCHOOLS at Wellesley, and NEUROPSYCHOLOGY AND INSTRUCTIONAL DESIGN at Harvard.

When students' interests overlap strongly with another department they may use VIII-B to help facilitate a double degree. Some go even further. One student crafted a focus in biological physics entirely from subjects in the biology department. I asked her if she was planning on getting a second degree. She said, "Yes, in math." Another student earned degrees in Physics and in Earth, Atmospheric, and Planetary Sciences; his VIII-B focus was in science writing.

Physics has the reputation of being a daunting major, one of the most difficult at MIT. In the past, some students who were fascinated by physics but unsure of their ultimate interests or their own abilities, may have been reluctant to embark on a major in physics. For those, VIII-B can act as a safety net. For example, one VIII student was unable to finish his senior thesis due to a major illness in his family. He was able to graduate by shifting to the VIII-B program.

One surprise is the attraction of the VIII-B program for some students who *do* go on to a Ph.D. in physics. It allows them the freedom to begin work in their chosen area earlier than they could have otherwise. One student with an interest in the theory of solids used as his focus three physics graduate subjects in the area, concluding with STRONGLY CORRELATED SYSTEMS IN CONDENSED MATTER PHYSICS. Another student interested in theoretical physics used three graduate subjects including RELATIVISTIC QUANTUM FIELD THEORY I and GENERAL RELATIVITY.

TABLE 2
Examples of Focus Group Topics

Astrophysics
Biological Physics
Computational Physics
Cosmology
Electronic Devices
Electronic Materials
Environmental Policy
Field Theory
Fluid Dynamics
History of Science
Management
Nanomechanics
Neuroscience
Non-linear Dynamics
Nuclear Reactor Physics
Philosophy of Science
Physics of Fusion
Planetary Atmospheres
PreMed
Public Policy
Quantum Computation
Russian Science
Science Education
Science Writing

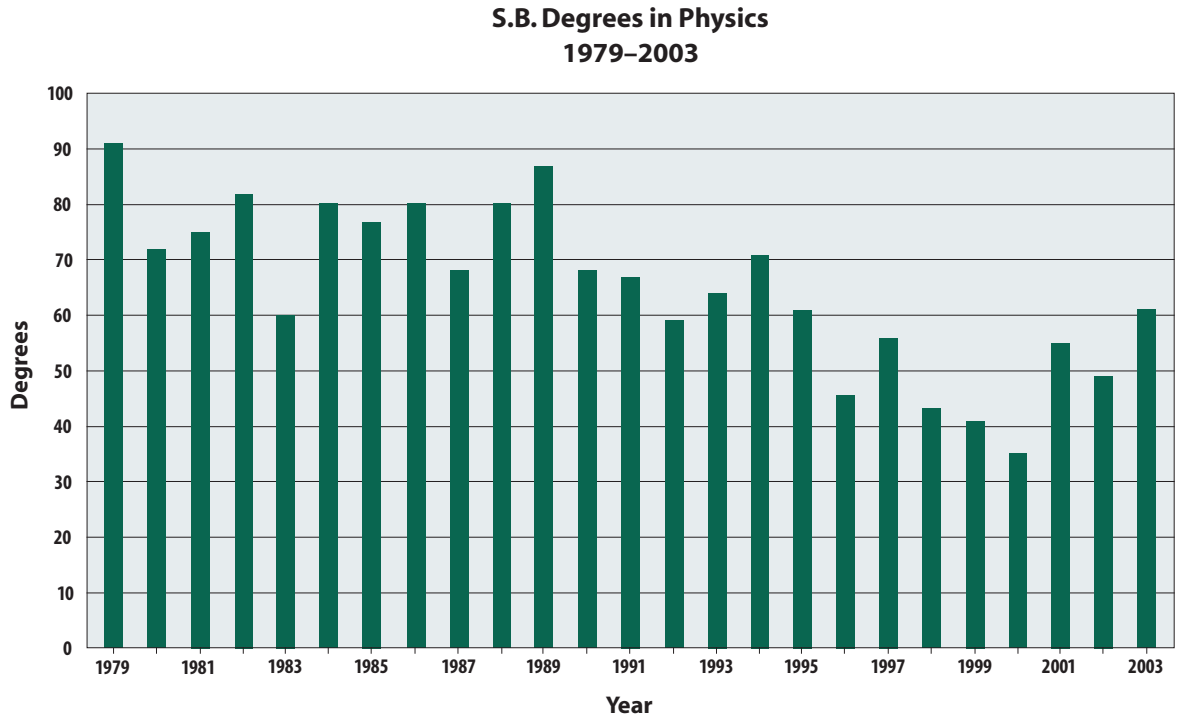

FIGURE 1
S.B. Degrees in Physics 1979–2003

Figure 1 shows the number of S.B. degrees awarded in physics at MIT over the past 25 years. The last three years, those in which the VIII-B degree was offered, show a definite reversal of the previous downward trend. This year we awarded 61 S.B. degrees in physics, more than in any year since 1995. The number of physics majors in the sophomore and junior classes indicates that the trend is likely to continue. Exactly how much of this rebound can be attributed to VIII-B is hard to determine. The nationwide statistics also show a turnaround, although with a much smaller percentage growth, due to changes in the economy and the job market. Also, in the past few years we have had a particularly effective group of faculty lecturing to our undergraduate majors. They have helped the reputation of the Department to grow among MIT undergraduates. Nonetheless it seems that the new degree has played a significant role in the increased popularity of our degree.

Figure 2 shows how our recent graduates are divided among our three programs, VIII, VIII-A, and VIII-B. This year, 49% of our graduates chose VIII-B. For the VIII-A program, Physics with Electrical Engineering, the student must take five core subjects in electrical engineering in addition to the requirements for the VIII program. Many students who would have taken this program in the past are now using VIII-B to get two degrees, one in Physics and one in Electrical Engineering and Computer Science. Double degrees have

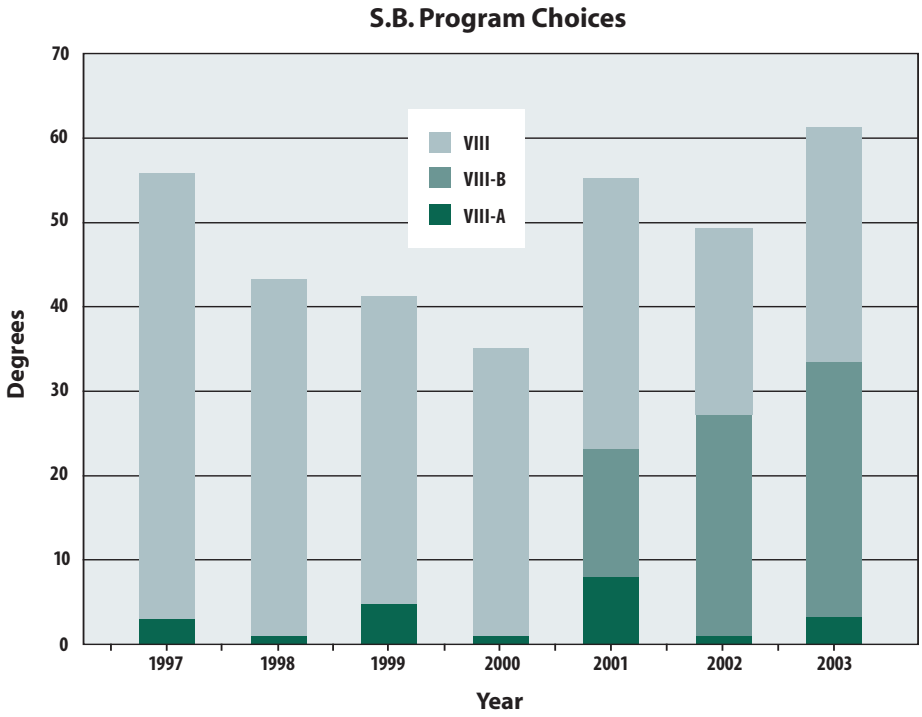

FIGURE 2
S.B. Program Choices

always been popular with our graduates but have become more so recently. Forty-seven percent of our students received double degrees in the three years before the introduction of VIII-B. This year 61% of the VIII students and 77% of the VIII-B students received two degrees.

The VIII-B program is just one of several successful initiatives relating to the academic side of the Department in recent years. Others include changes in the number and content of our undergraduate subjects, a comprehensive review of our graduate program, and the creation of a studio-based version of freshman physics. All of these initiatives are part of an effort to keep up with the changing role of physics and physics-based careers in the modern world.

THOMAS J. GREYTAK *received S.B. and M.S. degrees in Electrical Engineering (1963) and a Ph.D. in Physics (1967), all from MIT. He joined the physics faculty as an Assistant Professor in 1967, was promoted to Associate Professor in 1970 and to full Professor in 1977. He spent the 1972–73 academic year on leave at the University of California at San Diego with John Wheatley, studying the newly discovered superfluid phases of 3He. Professor Greytak was the Division Head for Atomic, Condensed Matter, and Plasma Physics from 1988 to 1997. From 1997 to the present, he has served as Associate Department Head for Education. His teaching interests include statistical physics, quantum mechanics, and condensed matter physics. Professor Greytak is a Margaret MacVicar Faculty Fellow and a Fellow of the American Physical Society and the American Association for the Advancement of Science.*