

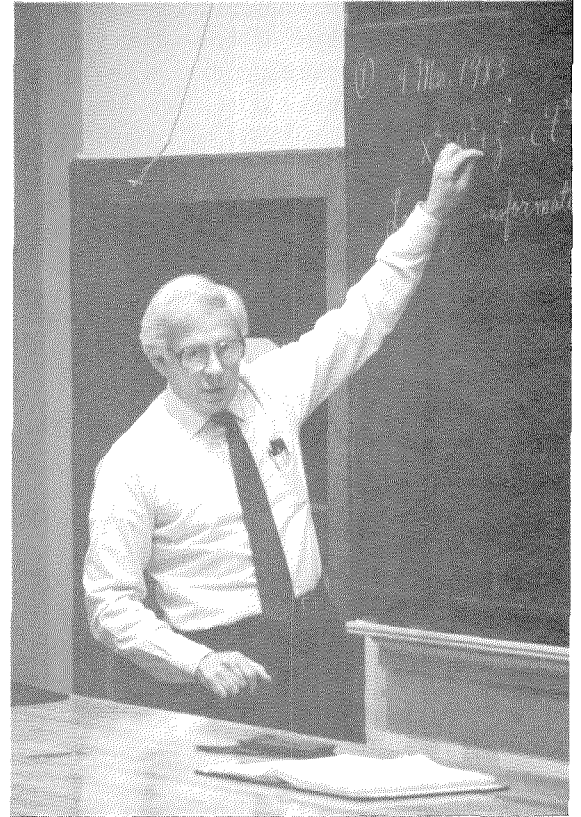
A Duty to Profess

IN HIS inaugural address in 1978, Caltech President Marvin Goldberger noted that “the material in the undergraduate curriculum is necessarily difficult, but it is also frequently boring and the students become disillusioned and impatient. In an institution like this, where the faculty are engaged in important and absorbing research and scholarship, it is often tempting to avoid giving undergraduate teaching the attention it requires to instill a sense of excitement in the students. I want to urge the senior, most distinguished faculty to undertake this task, but I warn you, it is much more difficult than graduate teaching. I’m sure our faculty, some of whom I’m told have never taught undergraduates, can cope with the difficulties.”

This year, hoping that “many of the senior faculty will follow my ‘brilliant’ example,” Goldberger coped with the difficulties of the winter term of Physics 1 himself.

The move was not without precedent; even Robert A. Millikan taught the freshman introductory physics course. Caltech has always “trained its very biggest artillery on the problem of freshman physics,” according to David Goodstein, a physics professor who also saw some action in the field. An eminent parade of faculty has tackled the course at one time or another, including Nobel laureate Richard Feynman, whose famous three red books, *The Feynman Lectures on Physics*, emerged from the experience in the early 1960s.

But by the time of Goldberger’s inaugural speech, the point had been reached “where Physics 1 was the number one student complaint,” says Goodstein, who is modest about which piece of faculty artillery was rolled out on that occasion. Goodstein’s version of Physics 1 (Classical Mechanics and Electromagnetism) was so good that the freshmen returned to griping about the food instead. But then Goodstein himself, fortunately or unfortunately, was lured into turning his physics show into a national television course — “The Mechanical Universe,” funded by a



\$2 million grant from the Corporation for Public Broadcasting and the Annenberg School of Communications.

This left Geoffrey Fox, whose job as executive officer for physics is to staff the course, with a tough act to follow. So he started at the top. “I knew that he was supposed to be a good teacher at Princeton, and I thought it might demonstrate the ‘specialness’ of Caltech for students to be taught by the president,” Fox said.

The president, who is a professor of physics as well, feels that “it’s the duty of all professors to profess. Also, I was very impressed with the changes that had come about in the teaching of the fundamental physics curriculum since I arrived here. Only faculty members are in charge of the recitation sections associated with the course, which is consistent with my own views about undergraduate education.” Recitation sections are led by faculty from other disciplines as well as physics. And two other professors of physics have shared the year’s lectures in the other two quarters — Ed Stone, who was project scientist for the Voyager missions to Jupiter and Saturn, and who has recently been appointed chairman of the Division of Physics, Mathematics and Astronomy, and Charles Peck, whose Crystal Ball research is described on page 4 of this magazine.

In his part of the course Goldberger has essentially followed Goodstein's "canonical" plan and doesn't claim to have done "anything even evolutionary, let alone revolutionary." But his lectures carried the stamp of some of his own concerns and experience. He thinks that "it's very important for an introductory course to try to convey some of the history associated with the development of a subject. It's not that I believe that one should try to drag the students through all of the agonies and false starts that really mark the actual evolution of the subject, but rather to give some flavor for what the general state of knowledge was at a given historical time. I want to dispel the idea that students sometimes have, because of the way we teach, that everything is really relatively simple and straightforward. Most of us have had the experience of doing research on hard problems where we struggle for weeks or months, and once we've finally understood the matter, we can explain it in ten minutes." Goldberger regrets that he didn't have enough time preparing for the course to "acquire a deep enough feeling about the historical evolution of many of the topics I covered to transmit enough of that flavor." This was not the only difficulty Goldberger had to cope with; there were also the demonstrations.

"Physics is an experimental science, but in my former life I was a theoretician, and I've consequently not been in a position to put as much emphasis on the demonstrations as an experimental physicist would have, and perhaps not as much emphasis as the students might have liked." Demonstrations bored Goldberger when he was a freshman, but he realizes that many students like them. Before his lectures he was sometimes advised by physics staff member Tom Harvey, who once worked for Millikan, to put things out on the table even if he wasn't going to use them, just so the students would think he was going to perform something exciting. Goldberger laments that in teaching relativity, which he was beginning as the quarter ended, "there are just not a lot of experiments you can do. I can't come running across the lecture room at speeds approaching the speed of light. I wish I could, but I can't."

Goldberger frequently covered all nine blackboards in the lecture hall with equations. (In the particular lecture shown on the cover, he managed to use only six, since part of the hour had been taken up with some film footage — pinch-hitting for a relativity experiment — of Einstein's 1931 visit to Caltech.) One complaint about Goldberger's presentations has been that he used too many complicated calculations and not enough intuitive arguments.

"The last is a very subtle question, this business of trying to teach intuition. It's an extraordinarily difficult thing to do. I've never been a great believer in what you might call 'physics for five fingers.' The compelling intuitive arguments almost invariably follow hard analysis, which we frequently and most commonly couch in mathematical terms because we're incapable of carrying out a lot of the steps of logical reasoning without using mathematics. As I said, physics is an experimental science, and the mathematics must always be kept subservient. Nevertheless, it's an extraordinarily effective tool, and it's impossible to be a physicist without being comfortable with mathematics."

Even with all his traveling and other presidential duties, Goldberger missed only two classes during the quarter. He enjoyed teaching but found it time consuming. "My schedule is so erratic that I've occasionally found myself under enormous pressure trying to get ready for a particular lecture. I've always found in the past when I've taught that for the most part I did nothing else, and although the actual preparation for an individual lecture might not have required more than a few hours, I was always thinking about how I was going to say things and various nuances that I would try to get across. It's the absence of that kind of time that's made this particular teaching experience more difficult."

Goldberger hasn't yet decided whether he will teach the course again next year. But in the meantime he is trying to shame others into taking on a quarter or two; he particularly has his eye on Nobel laureate Murray Gell-Mann. At least now, says Charles Peck, who took over the final quarter this year, "I think no professor can tell him, 'I'm too busy to teach.'" □ — JD

