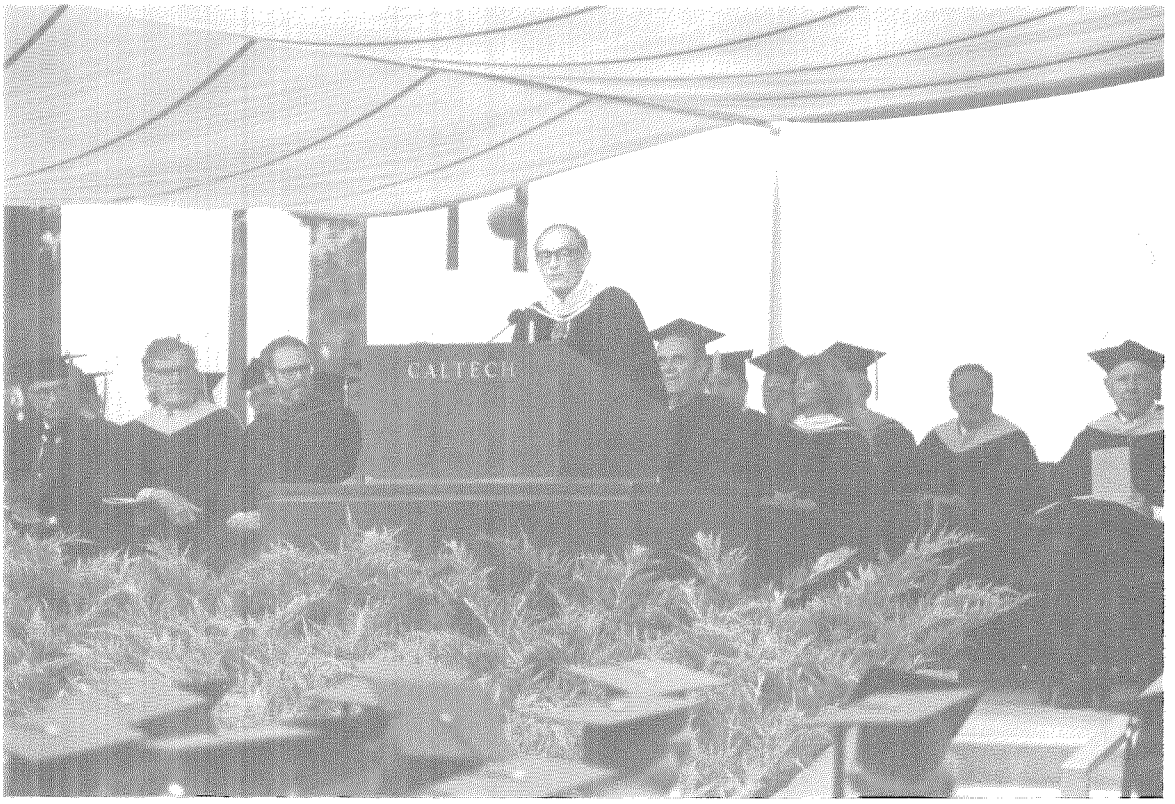
Commencement 1982



To Know, To Understand, To Do

by Hans W. Liepmann

I HAVE BEEN asked to address this 1982 commencement convocation, probably because of my endurance at Caltech. After all, I have spent just about ten times as much time here as any of you whose graduation we celebrate today. Have I learned ten times as much as you? I would rather not answer or discuss this question but sidestep it with the excuse that I have never been on the receiving end — I left this to my sons.

You down there who are at the end of the GPA [Grade Point Average] rat race may well snicker and think that the old fool did not know what else to do but to stay here. Well, this is a possible conclusion, but there may be another. Stop and consider the possibility that Caltech is more than an expensive penal institution but has conceivably attractive, even addictive, features that are worth preserving.

You, the graduates, and I have in common that we came here to learn, to understand, and eventually to be able to use the learning and understanding to contribute to a chosen field in a chosen way. How to design an institution, a system, that enables these goals to be reached in an optimal way and still remains inhabitable, is a subject of much theory and even more experimentation.

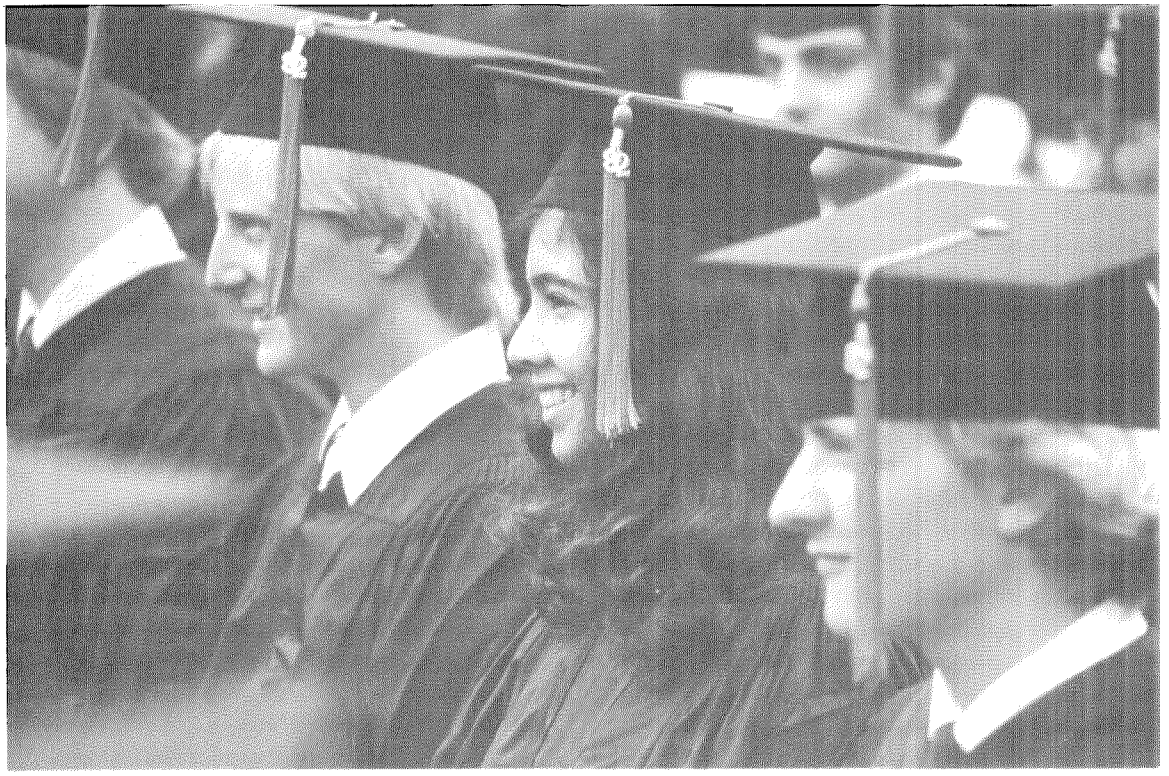
As in thermodynamics, we have to separate a system from the universe and we have to find an enclosure for this system with suitable properties. The completely closed system, the ultimate ivory tower, will not do; its entropy will surely increase, and all action will cease. A completely open system will exhibit the wild fluctuations reflecting the often chaotic state of the surroundings, an environment not particularly suited for learning and certainly not conducive to understanding. Between these limits there must be an optimum; but since people, even students, unlike atoms are still always distinguishable, the best one can hope for is an optimum for a specific set of students.

The common, rigorous, core program in the natural sciences with a strong backing in the humanities, together with the deliberate restrictions in size and the aim toward excellence in selected disciplines only, defined the enclosure since the beginning of Caltech. It was, fortunately, modified some time ago to make it permeable to an additional subset of humanity — women. (I do hope that this subset remains distinguishable from the other!)

Within this framework, which sets us apart from other larger schools, we should be able to create and preserve an atmosphere which combines intensity and rigor of study with warmth and companionship. An atmosphere in which learning and teaching facts are enjoyable challenges, with enough slack and leisure to understand old ideas and pursue new ones. An institution in which the faculty has enough time to interact with students and each other and where research at the leading edge diffuses through the whole educational process. A fraternity of scholars where ambition and striving for excellence is free of petty jealousies.

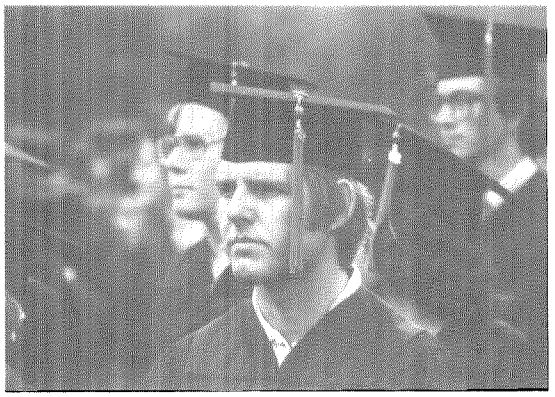
To accomplish such an aim we have to preserve not only an enclave of excellence but also of trust. This is trust between the members of such a community, openness of exchange of ideas, respect for differing thoughts. This is a very tall order and like any asymptotic state hardly fully attainable. We are fortunate that we do have a head start at Caltech. We have a crucial ingredient, a functioning honor system, based on the premise that no member of the community should take advantage of another! We still have the pick of students and faculty. We have an academic administration small enough and competent enough to do what I consider the only essential administrative job: to protect the ones who contribute most from the ones who contribute least. Add to all this a very effective board of trustees and our loyal alumni, and we should have it made. So why are we still far from the ideal? What makes the aim so difficult to achieve?

Well, we deal with people with abilities and idosyncracies not easily codeable on an IBM card. In selecting students and young faculty, we can measure the voltage, the straight I.Q. type ability, reasonably well. But the output, the ulti-



mate accomplishments, should be measured in watts. The current — that is, the ability to apply the intelligence, the necessary perseverance, power of concentration and motivation, let alone imagination — is much harder to evaluate or predict. In the tendency toward a more "democratic" form of faculty promotion and selection we have certainly successfully decreased the chance of petty tyranny and discrimination. But could we today appoint a professor with a patent office background like Einstein's, or a high school teacher like Weierstrass? Could we discover and document a candidate who publishes in the obscure proceedings of a minor academy like Gibbs? I wonder!

Historically a university is a nonlinear unstable system: a mediocre group will select and attract mediocre members and tends to become worse. An excellent group will tend in the other direction — the desired one. In addition, excellent mem-

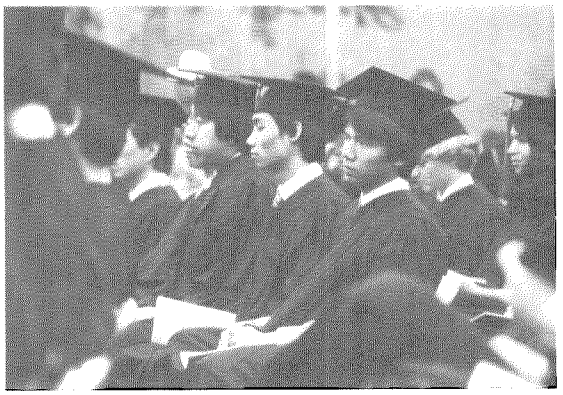


bers are moveable, mediocre ones less so, and hence a sudden decline of the quality of a university can and does happen. Preoccupation in the faculty with research and publishing at the expense of teaching is an age-old problem as well and, by the way, not too different from the preoccupation with GPA at the expense of learning and understanding in the student body. Evaluating successful, creative teaching is by no means as easy as it looks. The distinction between smoothness and elegance of presentation versus depth of penetration of a field is often quite difficult. Maybe you down there should contribute to a TQFR [Teaching Quality Feedback Report] again five years after graduation!

Direction of effort, choosing promising new avenues, often requires decisions whether or not an opening field is full of promise or full of propaganda, an exciting opportunity or merely a fashionable bandwagon. Missed opportunities and, even worse, choice of spectacular trivialities are bound to occur occasionally.

To these classical problems has to be added a modern dilemma. The noise level has increased throughout academia by orders of magnitude. The increase in the number of publications, meetings, and committees is at least exponential in time; even the task of *turning down* paper and proposal reviews, meeting participation, and committee memberships takes a reasonable length of time, let alone accepting, preparing for, and participating. There are times when the old ivory tower looks very attractive indeed. Still, a loose coupling with the outside world is, of course, essential to keep in tune with the times, to feel the pulse of both a rapidly changing technology and rapidly changing attitudes and needs. But within our enclave there must be room for the odd ball, not only for the entrepreneur. Intensive work and extensive show have to keep a reasonable balance.

These then are our difficulties. How well have we dealt with them? With the help of some undergraduate spies I tried to find the student reaction, an association with the word "Caltech." The result was quite positive — *hard work plus comradeship sum it up quite well.* But I realize, of course, that experiment and experimenter are not independent. There does exist discontent and resentment. I, like some or most of you, regret the apparently ever increasing problem-set syndrome — the feeling of always being behind. I also regret the increasing tendency to rigid curricula since both reduce the time for contemplation, exploration, and fertile leisure, and thus tend to eliminate or at least reduce the enthusiasm for learning as well as any cross-fertilization. There are a number of reasons for this trend but one out-



standing one: the rapid explosion-like expansion of the limits of all fields in natural science and engineering.

In the preface to one of the earliest monographs on relativity by von Laue written in 1911, the prerequisites are stated as "the usual mathematical tools of the theoretical physicist, calculus and vector analysis," less than what you are supposed to have mastered at the end of the freshmen or, at most, sophomore year. In engineering for many years, thermodynamics and steam tables were synonymous. From my experience in applied sci-

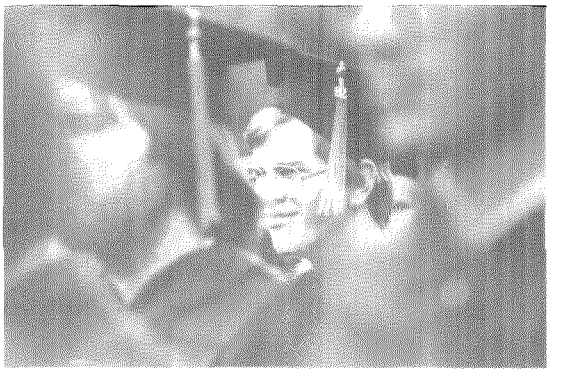
ence and engineering, the usual way for a faculty to approach the structure of a curriculum is to begin with a question like this: What should an applied physicist, say, know today? If this knowledge is to be supplied entirely by formal classroom teaching, the result is obvious: a dense set of tough required courses that leaves little time for electives and even less for musing. This type of approach is quite difficult to avoid but it is, I believe, orthogonal to the real aim of Caltech. The aim has been and should be to turn out professionals that are not narrow specialists but on a basis of solid fundamentals are *able* to specialize and *change* specialization. Required courses, like publications, should follow Gauss's maxim — *pauca sed matura* — few but excellent!

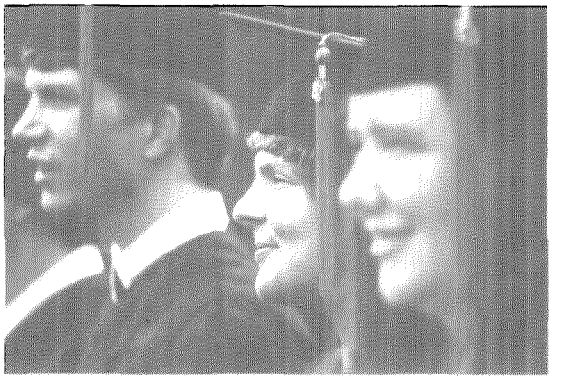
In this context I would like to repeat a modest proposal I once made, not quite in the spirit of Swift — I do not advocate the eating of faculty by the students or vice versa — that one week added to the Christmas and Spring recesses, or a free week around midterm, would go a long way in helping to regenerate and revitalize souls downtrodden from an excess of problem solving. A minor change but I think quite important for the coming crop of students, the ones who remain. Furthermore, to make the GPA race reasonable, a way has to be found to convince all universities and industry that grades here (graduate and undergraduate) mean what they say; that a Caltech C is a respectable grade and not a consolation prize for flunking out! Straight A's, a 4.0 GPA, may indicate an impressive intellect or a depressing lack of interest.

So we have not yet reached the ideal, and we will probably never quite get there. But the spirit of academic fellowship and the drive toward excellence is still alive here. Caltech remains an irreplaceable singularity among the schools in this country that we hope to preserve intact and that one does not leave lightly.

You, the graduating class, are leaving the system to meet the challenge of the surroundings — real life, as it is sometimes called. You can be proud to have finished a difficult obstacle course. But watch your pride: your way is not the only one. In your professional daily life you will meet people who know without understanding, understand without knowing, and act without understanding. All permutations are possible, and the results are by no means always bad — provided one excludes the case of acting without knowing and understanding, which happens as well.

You will have to face larger issues. Already the first practitioner of thermodynamics, Prometheus, challenged the gods, and they sent the alluring Pandora to earth. His simple-minded brother permitted the fatal box filled with evil to be opened. In our times a Pandora appears every few years, alluring as ever in her guise as atomic energy, computers, lasers, or genetic engineering, each time with real promise and real danger. I do not believe that there is a way to escape the Pandora syndrome. Somebody, somewhere, is bound to open the box. This syndrome may well provoke your public reaction, but before you climb a soap box, make sure it is very solid, and remember that responsibility, exhibitionism, and vanity are often hard to distinguish. Much more difficult is the ability to say: *One* does but *I* don't!





Whether we like it or not, we struggle on under the Chinese curse, "May you live in interesting times!" Well, at least life will certainly not be dull, and hope was, after all, the good gift from Pandora's box. Leaving Caltech to face the interesting times you should have two assets: competence and confidence. What I hope you will keep throughout your lives is the pleasure of learning, the pure joy of understanding, and the urge to contribute.

Felix Bloch recalled that at a similar state in his life he proudly declared to Heisenberg that space is simply the field of linear operations! "Nonsense," said Heisenberg, "space is blue and birds fly through it!" With all the encyclopedic knowledge and techniques stored in your memory banks now, it is well to remember that there is an outside world to see and enjoy. Add a fourth dimension: to know, to understand, to do — and to dream. □