The New Engineering Labs

Still hard work, but a lot more challenging.

The laboratory is clearly the foundation of experimental science and engineering, yet for the student it is also a major source of disenchantment. The reasons are basically the lack of flexibility and creativity in laboratory courses, compounded by the long hours the student must spend there.

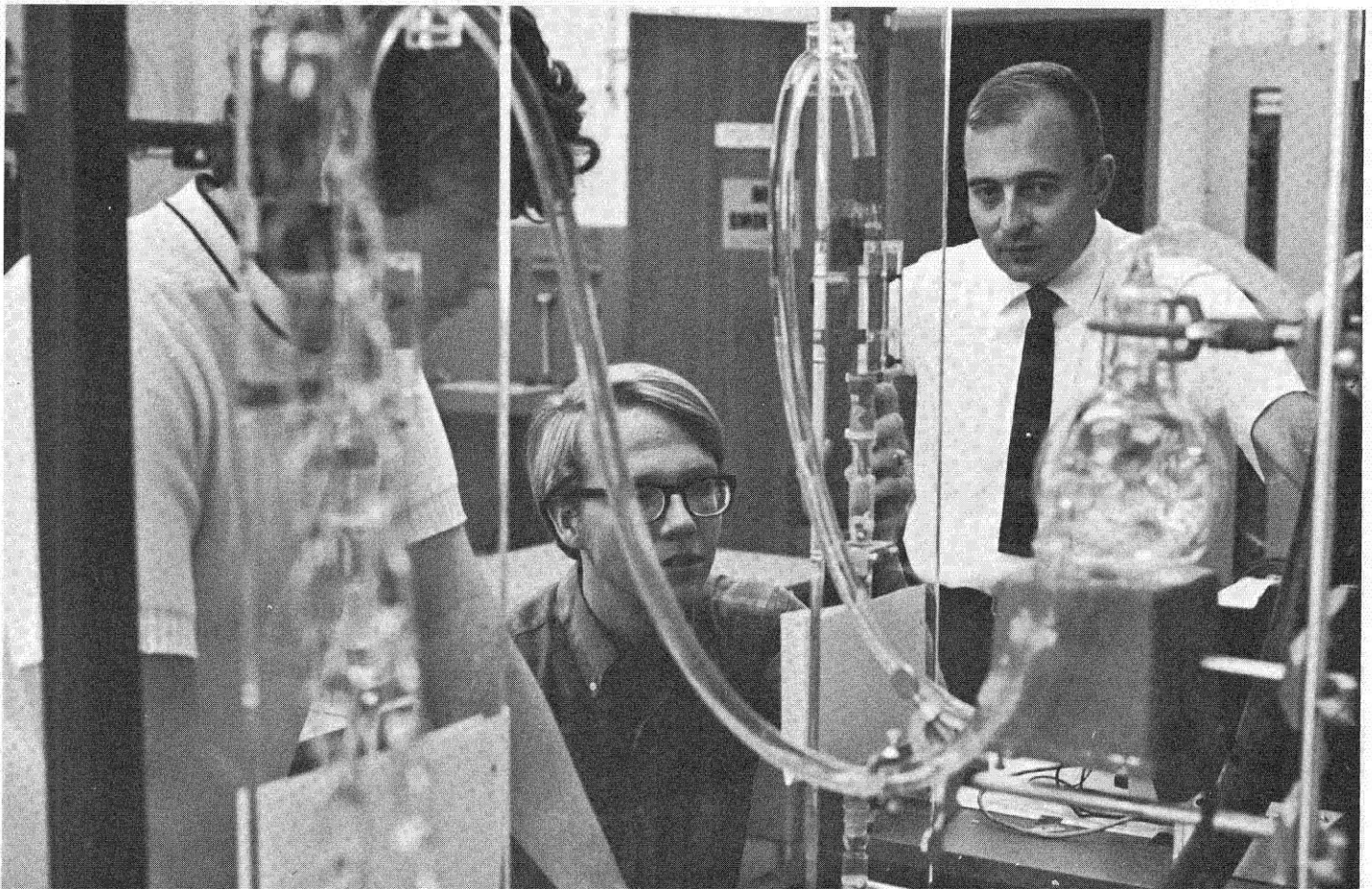
The problem for Caltech and other universities that aim to produce outstanding scientists and engineers is how to train students to conduct scientific experiments—capitalizing on their inherent interest in technical tinkering—without dulling their enthusiasm for research.

Three undergraduate courses at Caltech that provide some promising new approaches to laboratory instruction are EE 91 (Experimental Projects in Electrical Engineering and Applied Physics), which is taught by Floyd Humphrey, associate professor of electrical engineering; E 5 (Laboratory Research Methods in Engineering and Applied Science), a freshman course taught by Bradford Sturtevant, associate professor of aeronautics, in cooperation with seven other faculty members; and ChE 10 (Chemical Engineering Systems in Chemistry and Chemical Engineering), a freshman course taught by Frederick Shair, associate professor of chemical engineering.

Humphrey's EE 91 course is made available to a select number of seniors who have shown both the enthusiasm and self-discipline necessary for original experimental work.

Students learn to recognize their research interests in this laboratory course because they are required to create their own experiments. Humphrey gives students a week at the beginning of the course to write a proposal for their projects. "They learn that you either write your own proposal as an experimenter—or you do what someone else tells you to do," he says.

By requiring projects to be well-defined, Humphrey teaches students to formulate a unit of work and tailor their objectives to the time and facilities available. They also learn to make



Ronald Bohl '72 (left) and Allan Ferrand '73—with course instructor Frederick Shair—study the multiplicity of steady states in a nonlinear chemical reaction system as part of their E 5 project.

compromises in the design and depth of their experiments and to justify the use of various instruments, just as they would in any professional laboratory.

Facilities are available for experiments involving electronic circuits, electronic circuit elements, cryogenics, lasers, magnetism, optics, microwaves, plasmas, and electronic properties of semiconductor materials.

Although Humphrey always makes help available, students must learn to recognize their difficulties and know when to ask for assistance. Students are required to give a written and oral report on the results of their research.

"But," says Humphrey, "we're not interested primarily in the results; it's the student who wants to know the answer. We want him to do well whatever his particular experiment is."

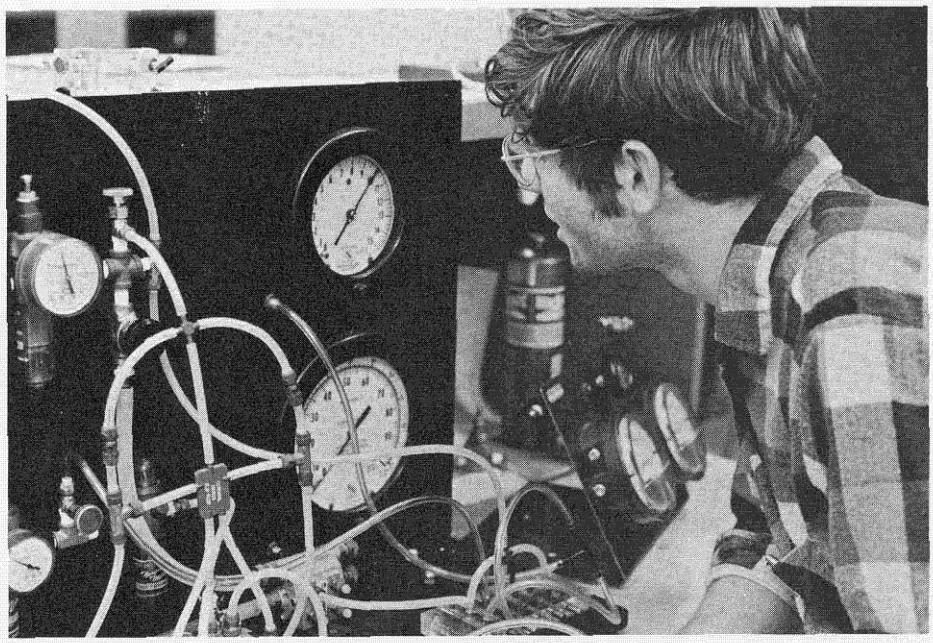
In the E 5 lab, a two-term course, freshmen are given a choice of experiments in fluid mechanics, nuclear engineering, digital communications, wave propagation, heat transfer, gas dynamics, materials science, solid state electronics, and chemical engineering.

The purpose is to give each student a feeling for the type of research he will be doing in the field of engineering or science he may eventually choose. Each student does four experiments that require two weeks of laboratory work apiece. Although the experiments are set up by instructors, students are given the widest opportunity possible, considering their level of experience, to make decisions.

Other instructors in the E 5 course besides Sturtevant are Fred Culick, associate professor of jet propulsion; Edward Zukowski, professor of jet propulsion; Mahlon Easterling, a visiting professor from JPL; David Welch, associate professor of engineering design; Rolf Sabersky, professor of mechanical engineering; Humphrey; and Shair.

In addition to providing some chemical engineering flair for E 5, Shair has been helping to develop the ChE 10 course, which was initiated by William Corcoran, professor of chemical engineering. During the past year students studied the artificial kidney. After several tours of hospitals and manufacturing plants, students chose one aspect upon which to do a term project. Some students conducted experimental studies of new membranes provided by a company. Other students consulted with physicians and helped to formulate experimental programs aimed at developing new and useful information. Emphasis was placed on the reason for doing an experiment along with an appropriate error analysis. In this course, each student participated in an oral presentation as well as being required to outline and write a formal report.

Neil Erickson '70 makes final connections on a capsule that will be taken down to 0.1 degree Kelvin for his cryogenic experiment in EE 91.



Rand Waltzman '73 tests a fluidics oscillator as part of his work in E 5.