Control Systems Laboratory

by Laura Schmitt

Each year, the Control Systems Laboratory is used to provide basic instruction in feedback control to more than 550 students from the departments of Electrical and Computer Engineering, General Engineering, Mechanical and Industrial Engineering, and Aeronautical and Astronautical Engineering. The facility and four smaller satellite labs—robotics and automation, mechatronics, fluid power systems, and flight control systems—provide both vertical and horizontal integration of control systems and related technologies across departmental boundaries in the engineering curriculum.

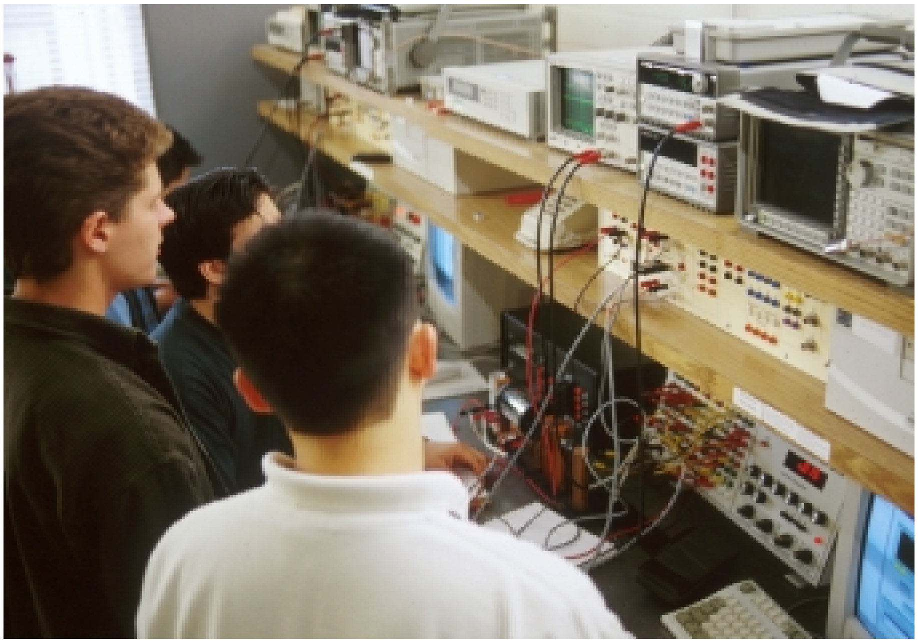
Before the creation of the Control Systems Laboratory, which is recognized as one of the premier undergraduate instructional laboratories in the nation, each engineering department ran its own controls lab to support its courses. Among the challenges each department faced was maintaining and updating its laboratory's equipment and experiments.

"None of the departments had recurring funds to keep the labs state-of-the-art," said general engineering professor Mark Spong, who served on the interdisciplinary committee that organized the concept for the laboratory in 1994.

"Control is a natural interdisciplinary topic since it is taught in several departments," said electrical and computer engineering professor William Perkins, who chaired the committee. "The control faculty has always interacted in terms of research, attending each other's seminars, and sending students to classes in other departments. It just made sense for us to explore a common lab facility that would satisfy several departments. And, it was helpful to have experiments developed by a group that is familiar with all the different aspects of control systems—mechanical, electrical, aeronautical, and so on. This produced a much richer set of experiments than any one department could design for its students."

The new facility was established with a $500,000 investment and relies on an annual $125,000 budget for maintenance, upgrades, and staff. The recurring budget comes, in part, from a tuition surcharge assessed to all engineering undergraduates. In addition to supporting the Control Systems Laboratory, the surcharge supports a mechanical testing instructional laboratory and workstation laboratories, which are also collegewide facilities.

The biggest advantage of the shared, collegewide controls labora-



tory is cost savings. Eliminating redundancy enabled the college to hire a full-time laboratory manager, Dan Block, who maintains and manages the daily activities of the Control Systems Laboratory. Block designs new experiments, updates software, maintains site licenses, repairs equipment, and schedules classes.

"The outstanding control laboratories overseas all have professional people associated with them, resulting in an industrial-grade laboratory," said Perkins. "The manager is an important component in this enterprise. But generally, in a departmental setting, you wouldn't have the resources to provide professional help."

Occupying nearly 2,000 square feet in Everitt Laboratory, the laboratory's 18 lab benches each contain state-of-the-art equipment and software, including a Hewlett-Packard function generator, multimeter, oscilloscope, programmable power supply, and visual programming language software. Six Hewlett-Packard dynamic signal analyzers are shared among the lab benches.

Students using the facility have the opportunity to conduct up to 41 experiments, including a electromechanical system called a Pendubot. Designed by Block when he was a graduate student, the Pendubot consists of two rigid links interconnected by revolute joints. The first joint is actuated by a DC motor, the second joint is unactuated. The nonlinear dynamic coupling between the two links presents some unique challenges. Among the topics that students studying the device can explore are system identification, linear and nonlinear control, optimal and learning control, robust and adaptive control, and gain scheduling.

Faculty members are pleased with the facility.

"Before, we had something that was antiquated and badly in need of upgrading," Perkins said about his former control systems laboratory. "Now, I find that the students are enthusiastic about the lab, and they enjoy working with all the modern equipment."

Block is excited about the lab and the positive effect it has had on the students' education. "I would have loved having this lab when I was a student," Block said. "I remember going into a lab and motors wouldn't work sometimes, and it was kind of frustrating. But now that we have more resources, the quality of the lab has improved dramatically."

What are control systems?

A good example of a control system is the cruise control on a car or truck. When the driver engages the cruise control, a computer maintains the vehicle's speed by appropriately adjusting acceleration to changing external conditions such as hills. The key to control is the use of sensory information (feedback) to make a system perform in a particular way. This requires adding a brain (logic) to a system to regulate it or make it perform to specifications. For engineering students in the Control Systems Laboratory, the first step in learning about control systems is speeding up or slowing down a DC (brush type) motor that spins when voltage is applied.

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Control Systems Create Wild Rides

by Tom Moone

Curt Peterson (BSEE '81) enjoys a roller coaster career. In fact, roller coasters *are* his career. Peterson is the director of engineering for AMtec, a company providing control systems to the amusement industry for rides that include roller coasters, flume rides, and rapid river rides.

Control systems are what keep the rides running smoothly. "For roller coasters, for example, control systems make sure the cars don't run into each other," Peterson said. "The control system dictates the motion of the cars."

The process of designing a control system begins with receiving the ride layout from the designer. Taking this layout and the design for the vehicles themselves, Peterson designs where the train stops, where cars are located in relation to one another throughout the course, and where they are controlled.

"The part most people don't realize is the long hours and the tremendous pressure when opening a ride," Peterson said. "Because the control system is the last thing to be installed and integrated, and because there are always construction delays—without allowing delays in the attraction's grand opening—my schedule is always compressed to about one-third of what I really need."

Some jobs have provided unusual experiences for Peterson. In Las Vegas, the 1,149-foot-tall Stratosphere hotel has a ride at the top of its tower called the High Roller, a roller coaster that sends passengers careening around the outside of the tower over 900 feet above the ground.

"Working on top of the Stratosphere for six weeks before they installed any fencing was like living on a space station," said Peterson. "I felt very removed from the planet. Being in the control room as it swayed back and forth in the wind felt like being at sea."

Among his current projects, Peterson is developing a new power-friendly acceleration launching system for Coaster 2000 (pictured), a pneumatically launched 190-foot tower coaster that will travel at 80 mph. Ride cars will be launched at 4g. Current technology launches at a maximum of 1.5g using a great deal of power. At last report, the coaster had achieved 0 to 71 mph in 2 seconds.

In addition to designing controls for the High Roller ride, Peterson has worked on the ET, Jaws, and Bluto & Popeye's Raft rides at Universal Studios theme park; Escape from Pompeii and Big Bad Wolf at Busch Gardens; and Ghost Rider, Windjammer, and Timber Mountain Log rides at Knott's Berry Farm.

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