Engineering EDUCATOR
The latest news about teaching tools, measurement technologies and innovations in engineering education

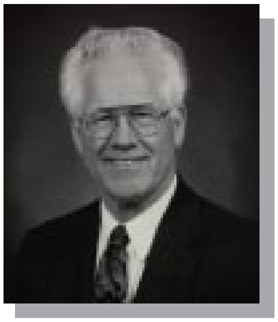
ABET 2000 Shakes Things Up

Lyle D. Feisel, Guest Editor

My father had some rather colorful expressions. For instance, when he felt that a situation had gone on long enough and something needed to be done, he would say it was "time to throw a skunk into the kitchen." The image of an angry skunk in the middle of a bunch of people who vowed not to move (change) is funny, but it suggests that there are ways to shake up an establishment and cause people to re-evaluate their positions.

About three years ago, the Accreditation Board for Engineering and Technology (ABET) threw a skunk into the engineering education kitchen. Engineering Criteria 2000, often referred to as "ABET 2000", is the first major change in engineering accreditation criteria in decades. It has, indeed, captured the attention of the education community. So is this particular skunk going to destroy the whole kitchen or is it just going to encourage the occupants to rearrange themselves? Let's consider the major changes.

Differentiation. While the old criteria pushed all programs toward the average, ABET 2000 encourages institutions to set their own goals—in consultation with their constituencies—and then design an educational program to achieve them. Of course, those goals can't diverge so far from the average that a graduate fails to qualify as an engineer. But the question of how far is "far" has yet to be answered. That will require some mature and responsible judgment on the part of program evaluators and the Engineering Accreditation Commission, but I think we can be optimistic. The important thing is that we can look forward to greater variety in our engineering programs.



ABET Criterion 3. Although institutions will have a great deal of flexibility in designing their programs, ABET 2000 does set minimum expectations. It is a list of abilities *(see page 9)* that every program must demonstrate their graduates possess. In my opinion, this is the most difficult—and potentially most important—criterion to meet. For instance, we know it's essential that our students be able to continue their education by learning independently. How can we demonstrate that they are?

Assessment. Every program must have a system for assessing how well it is achieving its objectives and must demonstrate how this evaluation is improving the education they provide. This seems to be the object upon which everyone is fixated, and I'm not quite sure why. As engineers, we are trained to write specifications, design a system to meet those specifications, and then test the system to see that they are met. Why is this different? My suspicion is that the real difficulty is not in the assessing but in writing the specifications in the first place.

Will the ABET 2000 skunk cause positive change? I think that it will, but there are those who feel otherwise. I can say one thing for certain, though; more people are having serious discussions about engineering education today than at any time in my memory. Whatever else happens, all this discussion is sure to have a positive effect.

Lyle D. Feisel, Ph.D., P.E.
Dean, Watson School of Engineering
State University of New York at Binghamton
Past President, ASEE

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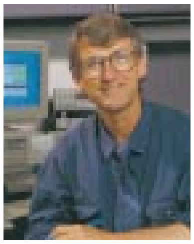
HEWLETT® PACKARD

Share Your Thoughts



This newsletter and the HP Educator's Corner Website (**http://www.hp.com/info/college_lab101**) are intended to help you, the educators responsible for shaping students into competent engineers. But to do a good job of meeting your needs, we need your feedback. Please e-mail your comments, questions and concerns to: *MARSH_FABER@hp.com*

Resources that are Naturals

The cartoons were great. (See **www.hp.com/info/college/lab_101**) Happy to see HP using humor positively. By the way, there are a lot of elderly people interested in using computers, and clear instructions are essential. [Elderly people] are not stupid, just a little slower in processing thoughts. In fact, many of them have compatible intellectual backgrounds (retired teachers, supervisors, etc.). I know many who are learning techniques from their grandchildren. Intergenerational activities anyone?

Betty O'Malley
Gerontologist/Humor Educator

I agree with you, Betty. It's amazing how we can overlook such wise, experienced—and plentiful—resources. Retired educators and engineers can be mentors and consultants for students as well as for industry. Readers: Any stories out there about how your school is using retired professors to enhance the learning experience?

Oops!

There must be an error on your website in the basic op amp modules section. The subtractor K2 should be negative.

Prof. Franz Josef Kuhn
FH Albstadt
Germany

Got us. We not only corrected the website, but for finding this rather nasty oversight, we also sent Professor Kuhn a small gift. Readers: If you're the first to find a serious error on the site, we'll send you something too, provided you sign your name! (Prof. Kuhn was actually the second person to find this, but the first person didn't leave a name.)

Recruiting Ideas, Anyone?

We are in the process of developing an undergraduate microwave program. We need some publicity/public relations to attract students to this "tough" track. Anybody's educational experience in this field is welcome!

Professor Martha Pardavi-Horvath
Dept. of Electrical Engineering and Computer Science
The George Washington University

Anyone have any experience that might help Prof. Pardavi-Horvath? My idea would be to get local companies with microwave products to come talk to students, show their products, and of course, mention that students with microwave backgrounds can typically expect a higher starting salary.

Just Half a Cup of Java, Please

I dislike the idea of using Java as a teaching tool. Isn't reality better?

Paul Evans
Physics Dept.
Harvard University

We are not in any way saying that Java as a substitute for hands-on learning. To us, that's like saying you can use a CD ROM to replace a good teacher. There's no comparison. We think Java makes a good platform-independent teaching aid that helps students see concepts that are hard to visualize. (See item on page 12 about the new Java Smith Chart.)

ISTEC URL

What is the current status of ISTEC? My stepson is a teacher in Mexico and would probably like help, but the info in the article relates to a 1990 meeting.

Prof. John J. Bertin
U.S. Air Force Academy

ISTEC is alive and well. Our apologies for not listing the URL. You can find ISTEC at: ***www.eece.unm.edu/istec/.***

Editor's Note

Here's a good place to tell you that we've created a single location for listing URLs that are referenced or have something to do with articles in this newsletter. You can find them at: ***www.hp.com/info/educatorlinks****. Also, you can find current and past issues of this newsletter at* ***www.hp.com/info/college_lab101.*** *Look under "Teacher's Tools." Then under "Publications," select "Latest News."*

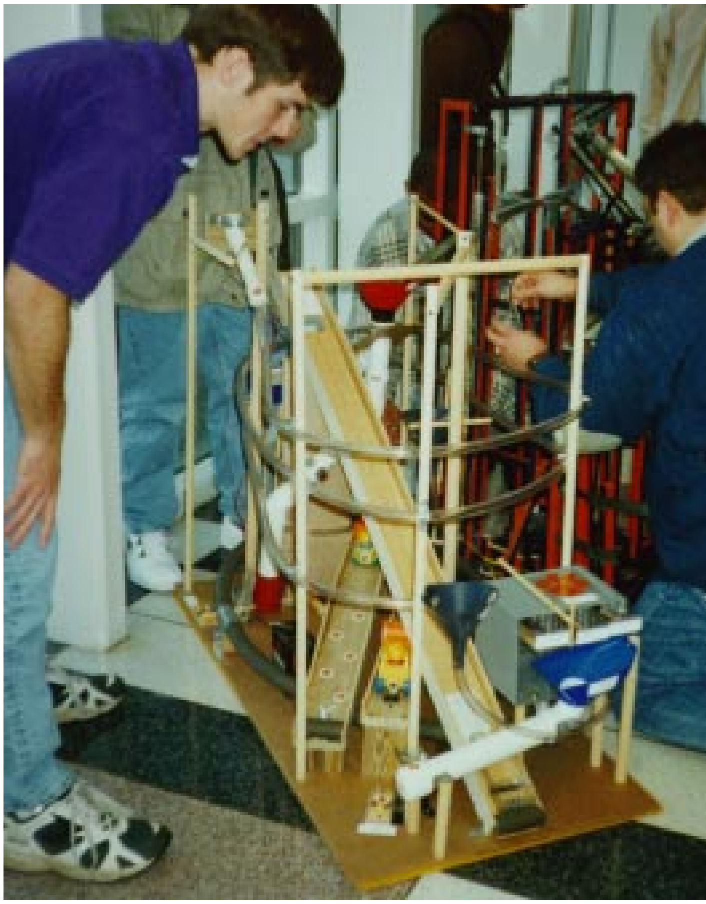
Engineering Contraptions: Zany Fun and Serious Lessons

"When I recall my own freshman experience from the mists of antiquity, the required freshman project stands out as the high point of the year. It motivated me, it involved me, and it made me think." So says Clemson University's Dr. William Park. With those memories and an idea he picked up at an ASEE conference, Dr. Park designed a Rube Goldberg* -style project as a centerpiece for his freshman engineering class.

According to Dr. Park, "This is my primary motivational tool for teaching engineering design and teamwork to freshmen. It's easier to teach students who are excited—and the goofy aspects of this project add a zaniness that appeals to kids right out of high school."

Built into all the fun, however, are some serious challenges. In addition to requiring computational skills using an HP48G calculator, Microsoft Excel spreadsheets, and MATLAB, the course includes estimation, graphical presentation and analysis of data, basic applied physics, and problem-solving methodology. Students work in teams to learn team dynamics.

continued on page 5



Tense moments as Dr. Park's students prepare for their final demonstrations.

A picture speaks a thousand words. This portrait of Dr. William Park, seen here… and here… will tell you as much about him as his curriculum vitae.

Dr. Park continues to define and refine his project formula, but it basically works like this:

(Steps are condensed for brevity. Please see website for complete article: http://www.hp.com/info/educatorlinks.)

- **Introduce students to the problem and provide examples of Rube Goldberg devices.**
- **Set up the teams (optimally, 4 per team) representing various skill levels and disciplines.**
- **Further define the problem, provide specifications, and impose numerous rules—"otherwise students will badger the professor to death."**
- **Conduct preliminary, trial-run demonstrations. Oral report required.**
- **Hold final demonstrations in a public forum and grade teams on results of three trials. Written report required.**

Premier Control Systems Lab Results from Interdepartmental Cooperation

In early October, more than 65 engineering educators from around the world met at the University of Illinois at Urbana-Champaign (UIUC) to learn about advances in undergraduate control systems instruction. A highlight of this National Science Foundation-sponsored workshop was a tour of the UIUC College of Engineering Control Systems Laboratory (CSL). One of the premier undergraduate instructional labs in the country, the CSL has a unique organizational and operating structure that serves as a model for other universities.

"In the space of a couple years, we went from having almost no labs to having the best controls lab in the country," said General Engineering Professor Mark Spong, who served on the interdisciplinary committee that organized the concept for CSL in 1994.

Before then, each engineering department ran its own controls lab to support its courses. Among the challenges they faced was maintaining and updating their individual labs with appropriate equipment and experiments. "None of the departments had recurring funds to keep the labs state-of-the-art," said Spong.

That's when the idea of a shared central facility began to evolve. A faculty group from the various departments developed the concept.

"Control is a natural interdisciplinary topic since it is taught in several departments," Electrical and Computer Engineering (ECE) Professor William Perkins said. "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."

Interdisciplinary Consolidation is Cost-effective and Efficient

The biggest advantage the college-wide facility has over the old department labs is a pooling of resources—a timely fit with the emerging ABET 2000 criteria. This interdisciplinary cooperation eliminates redundancy and ultimately saves money—and allowed CSL to hire a full-time lab manager, Dan Block (BS, MS General Engineering), who maintains and manages the daily activities of the lab.

The facility was established with a $500,000 initial investment and relies on an annual $125,000 budget for maintenance, upgrades, and staff. This recurring budget comes, in part, from a tuition surcharge assessed to all engineering undergraduates.

Each year the CSL provides basic instruction in feedback control to more than 550 students from four different departments—general, mechanical, aeronautical and electrical engineering. As a College of Engineering facility, the CSL 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.

The CSL's 18 lab benches each contain state-of-the-art equipment and software, including an HP function generator, multimeter, oscilloscope, programmable power supply, and visual programming language (HP VEE 5.0). In addition, six HP dynamic signal analyzers are shared among the lab benches.

CSL manager Dan Block oversees the daily activities of the 18-bench lab, which is used each year by more than 550 engineering students.

Students and Faculty Benefit

Students using the facility have the opportunity to conduct up to 41 experiments, including a UIUC-designed electro-mechanical 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.

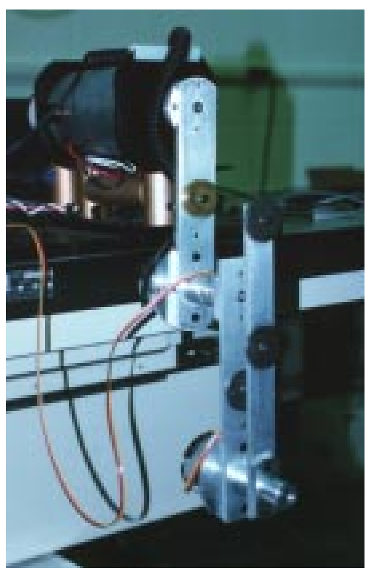
Laura Schmitt, Communications Associate,
UIUC College of Engineering

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

Andrew Saxsma, a 1997 electrical engineering graduate who now develops control systems for Caterpillar construction and mining equipment in Peoria, IL, is one such student. "The lab offers you a chance to apply what you learn with the guidance of people who really know what they are doing," said Saxsma. "Everything in the lab worked and I always had access to the right equipment."

In addition to using the lab for two classes, Saxsma completed a senior-design project for the lab. He and fellow electrical engineering student Dave Dobrilla (BSEE '97) developed a mathematical model and control system for a three-link Pendubot that is currently used as an instructional experiment in the lab. The three-link Pendubot is actually a doubly underactuated planar robot based on Block's original Pendubot design.

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." And all it takes is cooperation, coordination, and continuing care.



This Pendubot – a doubly underactuated planar robot – is currently used as part of an instructional experiment in the lab. Students develop a control algorithm and an electronics interface with a digital signal processing board to make the mechanical system (Pendubot) balance.

Zany Fun

(continued from page 3)

Says Dr. Park, "Students almost unanimously rate the project as the most enjoyable part of the course despite the amount of effort it requires. They are enthusiastic and emotionally involved in its outcome. An unanticipated side benefit for Clemson has been coverage in both newspapers and television news reports."

A paper by Dr. Park detailing his project methods appears on the web. You'll find a hotlink at **www.hp.com/info/educatorlinks.**

*Ruben L. Goldberg (1883–1970) American cartoonist and sculptor, creator of extremely intricate designs of contraptions designed to effect relatively simple results.

Lead Controller Design

Equipment needed:

- Amplifier/Motor/Potentiometer test set: *hybrid, built in house*
- Analog computer: *Comdyna GP6*
- HP 33120A Function/Arbitrary Waveform Generator
- HP 54600B 100 MHz Digitizing Oscilloscope
- HP 35670A Dynamic Signal Analyzer
- MATLAB or equivalent software

Our objective is to study the step response of the motor with a low dc-gain controller...

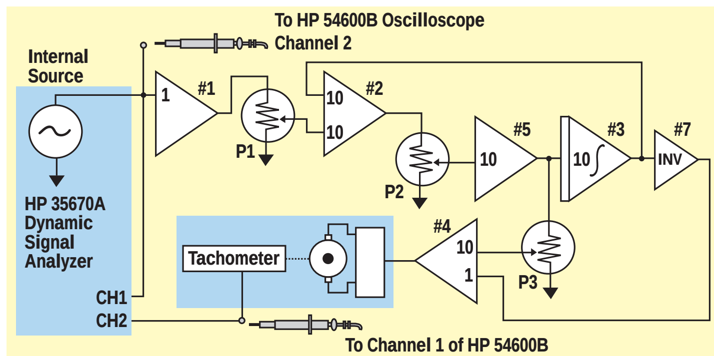


Figure 1. Wiring Diagram for motor with lead controller

Introduction: Motor control systems are a good means to help students internalize the fundamentals of control system analysis. This lab experiment uses a small motor controlled by an analog computer to show the advantages of a "lead" compensation scheme.

Lead compensators are a class of controllers that can be successfully used even when derivative information is not directly available. Lead compensators have the general form:

$$G_c(s) = K_c \frac{(1+s\tau_z)}{(1+s\tau_p)}$$

with $\tau_p < \tau_z$. The pole provides high frequency gain roll-off that results in less amplification of high frequency measurement noise than is observed with a PD (Proportional-Derivative) compensator. This is one significant advantage of the lead compensator. In this experiment, you will directly use a Bode plot rather than a root-locus plot to design the lead compensator Gc to meet these objectives:

- **Reasonable bandwidth**
- **Good transient response**
- **Good disturbance rejection to overcome motor friction**

Section I: Low DC Gain Lead Controller

The first section of the lab has two parts. In Part I, we'll attempt to control the motor's position by using a controller with low dc gain and then in Part II we'll increase the gain and observe the differences.

Part 1: Step Response with Low DC Gain Lead Controller

Our objective is to study the step response of the motor with a low dc-gain controller as described in the pre-lab1, (**www.hp.com/info/educatorlinks**). Since this is a Type I system, in the absence of disturbances the steady state error will be zero. This experiment will show that this compensator is not able to overcome the static friction of the motor. This will result in a large steady-state error in the step response. The compensator will be implemented using the analog computer. (Fig. 1)

Setup:

A) 33120A Function Generator:

Output Terminals = HI-Z (set this so function generator expects a high impedance load)

Then set:

Frequency = 200 mHz
Amplitude = 2 V p-p
Waveform = Square
DC Offset = 4 V

B) Make the analog computer and measurement connections shown in Fig. 1:

The relationship between the three potentiometer settings and the controller parameters is:

$P1 = Kc/10$
$P2 = 1/(1000{*}\tau_p)$
$P3 = \tau_z$

Turn on the analog computer and set its potentiometers (P1, P2, P3) to the parameter values corresponding to the low dc gain lead controller. See prelab at **www.hp.com/info/educatorlinks.**

Dan Block, MS General Engineering, Control Systems Lab Manager
University of Illinois at Urbana-Champagne

Connect the cable attached to the push button to Amp Inhibit on the patch panel.

Set the HP 54600B Oscilloscope to:

CH1 and CH2: ON, DC Coupling, 1 V/div. Move ground line to one division above the bottom of the display.

Main mode
Timebase = 50 ms
Trig. Mode = Normal
Trig. Level = 4 V
Trig. Source = CH 2

Connect the scope as shown in Fig. 1. You should see an input square wave on CH2. Turn on the motor amplifier. Put the analog computer in OPR (Operate ready) mode. Depress IC (Initial Condition) and then OP (Operate). Depress the push button and keep it depressed. The motor should respond to the step input, and you should be able to see the potentiometer output on the scope. If the motor starts spinning wildly, release the push button and check your connections, particularly those on the analog computer.

Using the scope measurement functions and then the cursors, measure the output amplitude, overshoot, rise time, settling time and the steady-state error. (See Fig. 2 for an example.)

Does the position of the flywheel before the step make a difference?

Note that the step response has a steady-state error. In between transitions of the square wave, physically rotate the flywheel with your fingers and observe if the controller is able to bring the motor back to its previous position. The control should feel loose, indicating a low dc gain. Measure the steady state error.

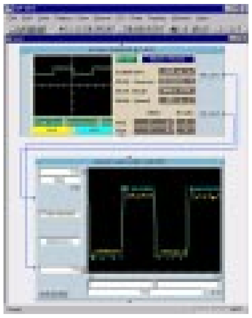


Figure 2. Low Gain case. "Loose" control.

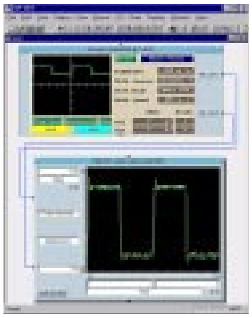


Figure 3. High Gain case. "Tight" control.

Part II: Step Response with Greater DC Gain Compensation

Now let's set the compensator to greater dc gain so that the control is no longer "loose".

Retain all the connections

Change the settings on P1, P2 and P3 to correspond to the controller parameters that you designed in the prelab (available at **www.hp.com/info/educatorlinks**).

Put the analog computer in OPR mode. Depress IC and then OP. Depress the push button and keep it depressed.

Note that the step response no longer has a steady state error. In between transitions of the square wave, physically rotate the flywheel with your fingers and observe if the controller is able to bring the motor back to its previous position. The control should feel much tighter than before, indicating a higher dc gain.

Observe the step response and measure the output amplitude, overshoot, settling time and rise time. (See Fig. 3 for an example).

This concludes the first section of the experiment. Section II continues with a measurement of Phase Margin, using the HP 35670A Dynamic Signal Analyzer and MATLAB software. For Part II and the complete version of this lab, go to **www.hp.com/info/educatorlinks.**

Amplifier/Motor/Potentiometer was built in-house using a variety of components.

Making Progress with ABET 2000

What makes a good engineer – and a good engineering school? The Accreditation Board for Engineering Technology (ABET) thinks its Engineering Criteria 2000 (or more commonly, ABET 2000) clearly spells that out. But what do engineering educators think? Based on the concerns raised at the ASEE National Convention last July, it appears that some embrace ABET 2000 wholeheartedly, most haven't made up their minds, and some would rather dismiss it altogether. Regardless, by the year 2001, schools that seek ABET accreditation will be expected to comply.

"...Like industries, schools must become more customer focused. Our customers are our students and the industries that hire them."

Some schools aren't waiting. New York's Union College, Georgia Tech, and California's Harvey Mudd College participated as pilot schools in 1997. Although new Union College engineering dean Dr. Robert T. Balmer was not involved in the process, he is very positive about its impact so far. "ABET 2000 is like a download of ISO 9000 concepts into academia—a process for continuous quality improvement. Like industries, schools must become more customer focused. Our customers are our students and the industries that hire them." In the autumn of 1998, 11 more schools underwent their first ABET 2000 audit. One of those was The University of Denver (DU) in Colorado.

By definition, early adopters are enthusiastic, but that seems an understatement when describing Dr. Albert J. Rosa, chairman of DU's department of engineering.

Dr. Rosa, who has been an ABET program evaluator for seven years, saw where ABET was heading and, with his faculty, began an in-depth analysis and overhaul of DU's engineering curriculum nearly four years ago. DU's five-year program, which is called Vision 2000, is actually more comprehensive than ABET 2000, but according to Dr. Rosa, "That's the beauty of ABET 2000. These new criteria are actually empowering. They give schools the flexibility and latitude to create curricula and programs that best meet their students'—and their schools'—interests. We will produce a new generation of engineers who are more competitive in the global industry." Dr. Balmer supports that view. "At Union, we are creating an Engineering Leadership Program for our seniors. The ABET criteria gives us the freedom to be innovative and create niche programs. It lets us be unique."

Some Observations and Advice about the Process

So what's it like to prepare for an ABET 2000 audit? Groans Dr. Rosa, "It's an enormous undertaking, requiring hundreds of hours of preparation and lots of cooperation. And remember, DU is only a small school with a single engineering department. We didn't have all the political and territorial issues that encumber larger, multi-department schools. They have much to overcome. Nevertheless, we had our share of disagreements and vigorous conversations. You can expect it to be part of the process."

ABET ABC'S

For those of you who are outside of the U.S, here's an overview of ABET 2000. ABET is recognized in the United States as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. It's a voluntary system that spells out objectives and standards for students, faculties, and facilities. These focus on quality and performance issues that can be measured and reported. The older ABET criteria emphasized teaching modalities. ABET 2000 criteria focus on learning modalities—with particular emphasis on **encouraging teamwork, interdepartmental or interdisciplinary activities, and vigorous communication.**

But ABET 2000 means a change from the ordinary, and change is controversial. At its source is ABET 2000's Criterion 3 (see page 9) which is "outcomes and assessment" based; that is, each program must have an assessment process that can produce documented results. There must be evidence, including design projects; nationally-normed subject content examinations; alumni surveys that document professional accomplishments and career development activities; employer surveys; and placement data of graduates—and that evidence must show that the results are applied to the further development and improvement of the program.

"The best advice I can offer to other schools is: Start early, prepare thoroughly, review repeatedly, re-evaluate regularly. These are the steps we took:

Study. We took a close look at some premier, innovative programs at schools such as Carnegie-Mellon, Rose-Hulman, Drexel, Worcester Polytechnic, and Trinity. We also reviewed the comments on the ABET self-study documents of Union, Harvey Mudd, and Georgia Tech.

Be inquisitive. We paid a great deal of attention to a self-assessment produced by Carnegie-Mellon on their revolutionary curriculum, and we invited Dr. Bruce Eisenstein from Drexel to speak to us on their educational experiments.

Meet. We held a faculty retreat where we looked at a draft proposal for change. We divided the faculty into three committees: curriculum, research and scholarship, and service. The curriculum committee met weekly to flesh out a new curriculum that emphasized interdisciplinary learning opportunities, teamwork, and communication skills.

Report. We prepared an extremely detailed report containing a financial analysis, enrollment analysis, as well as a step-by-step, year–by-year timeline for implementation. The dean, the provost, and the chancellor of the university embraced it wholeheartedly and it spent a year in the university approval process.

After that, the real work began. Implementing our ideas, collecting data, determining assessment criteria and methods, interpreting data, and preparing our own self study came next."

In our next issue, we'll take a look at The University of Denver's engineering curriculum and its rationale as well as its assessment and data gathering, analysis, and interpretation processes.

You'll find hot links to a lot more information about ABET and ABET 2000 at **www.hp.com/info/educatorlinks.**

You can also contact:

Modalities Accreditation Director
Accreditation Board for Engineering and Technology, Inc.
111 Market Place, Suite 1050
Baltimore, Maryland 21202-4012
Fax: (410) 625-2238
email: accreditation@abet.org

Dr. Albert Rosa leafs through one of many binders filled with evidence for DU's ABET visit. These exhibits are students' exams and assignments with examples of high, average, and poor achievement.

ABET 2000 Criterion 3
Program Outcomes and Assessment

Engineering programs must demonstrate that their graduates have

- **(a) An ability to apply knowledge of mathematics, science, and engineering**
- **(b) An ability to design and conduct experiments, as well as to analyze and interpret data**
- **(c) An ability to design a system, component, or process to meet desired needs**
- **(d) An ability to function on multi-disciplinary teams**
- **(e) An ability to identify, formulate, and solve engineering problems**
- **(f) An understanding of professional and ethical responsibility**
- **(g) An ability to communicate effectively**
- **(h) The broad education necessary to understand the impact of engineering solutions in a global and societal context**
- **(i) A recognition of the need for, and an ability to engage in life-long learning**
- **(j) A knowledge of contemporary issues**
- **(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

Engineering students tell us what they think

Several years ago, we gathered engineering educators from around the world for an Education Advisory Council meeting. Those educators gave us insight into the concerns and problems faced by engineering faculty, and helped us figure out what role we could play in solving those problems. You can see one result of that effort, the HP Educator's Corner website, at **www.hp.com/info/college_lab101.**

This past summer, we adapted the previous formula and invited engineering students from all over the world to give us a hand understanding their needs and concerns. Nine undergraduate students joined us for our first Student Advisory Council. We asked them a lot of questions during the week they spent in Colorado - and threw in a few fun activities (like mountain biking and whitewater rafting) as well. We sure learned a lot about what your students think, and we're currently in the process of developing a website based on what we learned. When it's complete, we'll let you know how to find it, so you can pass the news on to your students. You might even want to visit it yourself.

HP Student Advisors *Front row: (left to right): Jennifer Tittjung (University of Michigan, USA), Richard Alfonzo (New Jersey Institute of Technology/Seton Hall University, USA), Chong-Yuan Ng (National University of Singapore); Middle row: James Silva (Stanford University, USA), Chia-Hao (Jack) Yu (Stanford University, USA); Back row: Daniel Leonhardt (The Cooper Union, USA), Marcelo Motta (University of São Paulo, Brazil) , Ken-Hao Liu (National Taiwan University, Taiwan) and Alex Berman (Center of Technological Education Holon, Isreal).*

Some examples of what we heard:

"I don't always make the connection between theory and hands-on. I'm wasting my time in lab if I'm just following the cookbook lab procedure."

"I don't like the attitude that engineering is everything. I'm a person before I'm an engineer."

sac
STUDENT ADVISORY COUNCIL

"I knew that engineers had to get opinions of a lot of other people... but until yesterday [when I shadowed a design engineer] I hadn't realized the sheer volume of interaction that has to occur in order to finalize a project."

"It's great to discover that HP values my opinion. And it's great to see the amount of effort they put into finding out what future customers what."
Alex Berman

"I can honestly say that this is one of the best experiences with cooperation that I have had. I learned a lot of things during the course of this week in terms of constructive thinking and making an idea into reality."
Jack Yu

"It's fabulous that HP recognizes the importance of the corporate/student relationship. The council is a great way to strengthen that bond prior to graduation. I'm excited to be a part of it."
Jennifer Tittjung

HP Will Support National Engineers' Week

Continuing in the tradition of previous years, HP will provide financial assistance in 1999 to National Engineers' Week programs which bring prospective students–kids in junior and senior high–on campus to participate in lab tours, contests and more. National Engineers' Week is slated for Feb. 21-27, 1999. Find out more by visiting our hot links at www.hp.com/info/educatorlinks.

WEBSITE UPDATE

Keep an eye on **www.hp.com/info/college_lab101!** At your request we've improved the navigaton system and the layout—and we're trying harder than ever to keep the material updated and relevant.

Among our most popular features are the lab experiments submitted by engineering educators at various schools. Try out the new ones from:

- **Boston University**
- **University of West Georgia**
- **University of Michigan (a number of them!)**

And check out our newest online device—the interactive Smith Chart—use it to teach students about reflection coefficient, VSWR and load impedance.

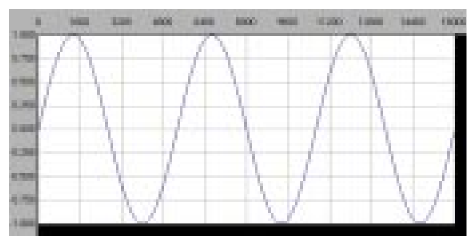
BRAIN TEASER

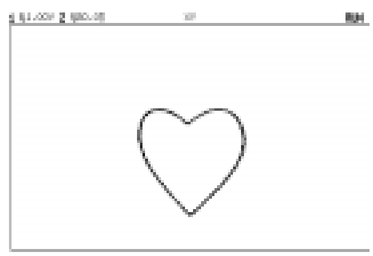
THE ROTATING HEART

Even if you don't call it Valentine's Day in your country, most cultures set aside a day to honor sweethearts. Here's a chance to design your own sweetheart greeting in true engineering fashion. This brainteaser was invented by Justan E. Steichen, junior engineering student at University of Colorado at Colorado Springs. If you have any puzzling experiments you'd like to submit, simply email your idea to: MARSH_FABER@hp.com

Our purpose: To demonstrate the versatility of Lissajous patterns —and to show that engineering lab managers actually DO have a heart.

Objective: Combine a sine wave and one other waveform to … display a rotating heart on the HP 54600B oscilloscope.





For the complete equipment list and procedure, go to www.hp.com/info/educatorlinks

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