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ENGINEERING EDUCATOR

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

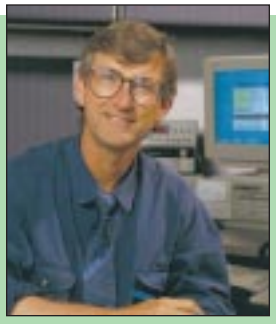
Volume 1 Number 1

IN THIS ISSUE

INSIGHTS

HP's Inaugural Edition

Marsh Faber, Editor



Why is the HP Test and Measurement Organization creating a newsletter just for educators? Developments in communications, networking, and computer technologies over the next 10-15 years will produce bigger changes in engineering and educational delivery systems than the past four hundred years combined. Possible scenarios include: Schools forming global consortia and students doing team projects with colleagues around the world, media companies creating and selling high-quality engineering course work, and industries commissioning a group of schools to produce course work specific to one job function. The changes will be breathtaking.

Very real benefits accrue to those who can rise to the challenges presented by such radical changes. New developments will give progressive, innovative educators like yourselves a host of new ways to reach inquisitive students. This atmosphere of change, combined with HP's strong interest in engineering education, are the driving forces behind YOUR new newsletter: HP Engineering Educator. HP has always enjoyed close ties with universities around the world, and this newsletter, we hope, will enhance those ties, make them more rewarding, make them even closer.

Each issue will introduce you, the professional educator, to new teaching and measurement tools, show you what your colleagues are doing, and help you keep up to date on new measurement technologies as they relate to education. Feature stories will allow you to make the most of new or evolving academic possibilities, as our cover story on retaining engineering students illustrates. Innovative and effective laboratory experiments are another editorial focus of this newsletter. The Equipment Update column addresses your budget concerns and presents ideas for acquiring HP products for your laboratory. Additional stories and columns cover products, literature, and other ways to make life in the lab easier for you.

Many of the newsletter's stories take advantage of the content available at HP's Educator's Corner website* (http://www.hp.com/info/college_lab101). This site offers many free resources, including powerful teaching tools (see "HP's Education Program Web Site: A Wealth of Free Instructional Aids," page 5).

In producing newsletter and website material, we receive excellent support and guidance from an editorial board of distinguished academics, but they don't represent everyone. We want to hear from you. Please contact us at marsh_faber@hp.com, or use the enclosed reply card. Let us know how we are doing, how we can do better, and how we can assist you to make the most out of the many exciting opportunities that inevitably accompany change.

Marsh Faber,
Education Program Manager
Electronic Measurements Division

**Note: This is a new website currently under construction. It is expected to be online in April 1997.*

Redesigned Lab Courses Help Reduce Drop-out Rates for Engineering Students

Dr. Robert G. Quinn

Freshman engineering students are among the best and brightest members of their peer group, yet far too few of them ever receive an engineering degree. In the United States, the average retention rate through graduation is below 50%, and typically over 25% of them drop out in the first year. This is an excessive, unnecessary loss of raw engineering and science talent, a tragic waste of human resources at a time when the technological revolution drives the economies of many countries around the world. Fortunately, much of this loss can be eliminated by reworking the education process.

In a major research study[1] conducted at colleges and universities across the United States, the principle reasons cited by engineering students for changing their major included "poor teaching by faculty," "poor advising and help," and "wrong first choice." This was a great surprise to educators, who believed that most engineering students drop out because they find the work difficult, lack drive, or seek to escape the work load. Significantly, the undergraduates' three issues also were a cause for concern among those students who remained in engineering. Clearly, educators have a mandate to create programs for more effective engineering curricula.

The College of Engineering at Drexel University, Philadelphia, Pennsylvania is one of the first institutions of higher learning to develop a new program that has demonstrated substantial results. The graduation rate among students in the Enhanced Educational Experience for Engineers (E4) program was approximately 70%-over 30% higher than a control group in the traditional engineering program. The experimental program proved to be highly successful in several other important areas, as well.

New academic paradigm

Based on these successes, over the past seven years Drexel University has enhanced its already outstanding undergraduate engineering curriculum. The enhancement is based on a new academic paradigm in which the environment and all academic activities focus on the students as emerging professional engineers from the very beginning of the educational process. The faculty serve a subsidiary role as mentors in a community of learners.

Implementing this transformation required a total subject matter reorganization; the invention, development, and/or use of several different teaching methodologies; and establishing state-of-the-art experimental lab facilities. Drexel educators benefited from lab quality HP test equipment and HP teaching tools.

When designing the E4 program, the faculty paid particular attention to the issues students raised in the research study. To address students' concerns about the effectiveness of teachers, they encouraged participating faculty members to engage their classes in greater levels of class discussion, with less emphasis on lectures. To meet student needs for quality advice and help, the educators implemented a more pro-active and better structured,

Continued on page 11

Photo of one of the student-built bridges being tested in the lab One E4 lab experiment challenges student teams to design and build a bridge using a standard kit of materials. Awards go to teams whose designs perform best when tested to destruction.

Measuring Mechanical Resonances of an Electromagnetic Speaker

Goals: Demonstrate the natural resonance frequency of a common device and how it can be measured; demonstrate the concept of signals buried in noise and show how they can be quantified.

Student group(s): First/second year engineering, with knowledge of Fourier transforms and scopes.

Basic equipment/supplies: Digitizing scope with at least 4 k of memory (more memory is better), and FFT capability; and an inexpensive electromagnetic speaker with a metal frame, such as a Radio Shack P/N 40-248.

Estimated completion time: 25 minutes

This multi-faceted experiment takes advantage of the fact that an electromagnetic speaker, which normally is used to convert electrical energy into sound energy, can also be used to generate electrical energy when external forces cause the speaker cone to move. The lab setup is simplicity itself: the speaker is connected directly to the probes of an oscilloscope. The procedure, too, is simple: the speaker becomes a signal source when the student drops it from a distance of about ten centimeters onto the hard surface of a lab bench. The digitizing scope captures that signal and stores some or all of the data in memory for display and analysis.

When the speaker hits the lab table, two things happen:
* Each time the speaker bounces, its exponentially decaying cone resonance signal quickly becomes apparent on the oscilloscope screen.
* The metal shell of the speaker produces an audible "klink."

The resonant frequency of the speaker cone is easily and directly measurable. A bigger challenge for the student, however, is to detect the ringing "klink" of the metal shield on the speaker, and thereby determine the resonant frequency of the frame of the speaker.

Scope memory affects procedure

There are two ways to do this experiment: A traditional digitizing oscilloscope can be used, an instrument with a relatively small memory depth behind each channel. The HP 54600B, which has a 4 kilobyte memory per channel, works quite well. A quicker, easier approach is to use a digitizing scope with a deep memory, such as the HP 54645A, which has 1 Megabyte of memory behind each channel (see page 6).

Using the HP 54600B scope, students should set the scope to trigger on single event, normal trigger. The first task will be to examine the main damped sinusoid. To capture that waveform, the student keeps dropping the speaker while adjusting the horizontal sweep speed. (For the speaker we used, the horizontal sweep speed that worked best was 5 ms/cm).

By viewing the first damped sinusoid signal, the student will easily be able to read the cone's resonant frequency.

Continued on next page

This experiment requires only an inexpensive (disposable!) speaker and a digitizing scope with FFT capability.

Introducing students to scopes

HP offers an operator's training kit, the HP 54654A, that is intended for use with the HP 54600-series digitizing oscilloscopes, as well as HP 54620-series logic analyzers. This kit contains a student manual and a simple function generator to create waveforms that present real-world triggering challenges. For information on this training kit, Check 8 on the reply card.

A free set of two "Visual Advantage" posters shows students how to operate the HP 54600 series scopes, and covers negative time, delayed sweep, storing and comparing waveforms, and more. To receive these free posters, Check 9 on the reply card.

The HP Basic Instruments Emulator is also available free to educators. This Windows based software package offers on-screen emulation of a digitizing scope, function/arbitrary waveform generator, and 6½ digit multimeter (DMM). Developed by Vanderbilt University, the emulator does not requires a physical connection to an instrument, and gives students an opportunity to familiarize themselves with the operation of test equipment before they come to the lab. To receive this free emulator, Check 10 on the reply card.

Measuring Mechanical Resonances of an Electromagnetic Speaker

Continued from previous page

(For our speaker, this frequency calculates to be about 300 Hz). But where is the "klink" frequency in the decaying waveform? It's there, but it can't be seen in the trace. To find the resonance of the speaker frame, the scope trace must be analyzed by the instrument's FFT capabilities.

To engage the FFT function on the HP 54600B, the student must push the Plus/Minus (+/-) key between the Ch1 and Ch2 buttons to turn on the math functions; set the Function 2 softkey to ON; push the F2 Menu softkey; toggle the Operation softkey until the FFT is highlighted. If the students want to change the FFT settings, they just push the FFT Menu softkey.

Scanning the FFT of the signal, the student will see that there are two main spectral peaks on the FFT's frequency spectrum readout. The primary peak is caused by the resonant frequency of the speaker cone. The student can use the scope's Cursors mode to produce a measurement value that should confirm the trace frequency measurement made in the time sweep mode. (For our speaker, this frequency was determined to be approximately 315 Hz.).
The secondary peak is at the "klink" frequency, the resonance that creates the metallic sound when you drop the speaker. (For the speaker we used, the "klink" frequency was about 2.4 kHz.)

Students can verify these measurements further by looking at an even smaller signal; for example, the third or fourth decaying sinusoid. To capture either one, the student should set the HP 54600B again to single event, normal trigger, then change the horizontal DELAY knob while repeatedly dropping the speaker, until the smaller signal has been centered on the screen. By engaging the scope's FFT once more, the student will again see the main resonant frequency, as well as the resonance of the speaker frame.

Only one drop needed

Performing the speaker-drop experiment with the HP 54645A scope highlights the enhanced analysis capabilities that are possible when you can manipulate and process all or selected portions of a complete, detailed record of the event. The HP 54645A's deep memory eliminates much of the triggering work that is necessary when a traditional digitizing oscilloscope is used, greatly simplifying the experiment, eliminating some sources of error, and reducing the time to find a solution. The most obvious benefit, however, is that now there is no need to drop the speaker more than once. The instrument produces real-time knowledge for students, with minimum frustration.

With the HP 54645A, the students drop the speaker just once and the deep memory scope captures the entire waveform, including all signals of interest. After simply stopping the acquisition, the students can study the first, second, third, or fourth set of decaying sinusoids, panning through the data record and zooming in on specific information AFTER that data has been acquired. The students can examine the signals produced by the individual bounces in the single event, and perform the FFT analysis on each one. The results should be the same.

When we performed the experiment with the HP 54645A, we tuned to the fourth damped sinusoidal signal produced by the speaker cone and expanded it on the scope screen. The signal amplitude was quite low and the "klink" resonance was really buried in the time-domain information – absolutely invisible in the scope trace. Yet by invoking the scope's FFT function, we could extract the resonant frequency of the metal shield from the second peak in the trace of the fourth bounce, confirming speaker frame resonance to be about 2.4 kHz.

In another version of the experiment, we dropped the speaker from a distance of about ten centimeters onto a thin paper pad placed on the lab bench. The "klink" went away because the paper pad was sufficiently resilient to dampen the vibration of the metal frame. Capturing the signal and performing the FFT, we verified that the "klink" frequency component had vanished.

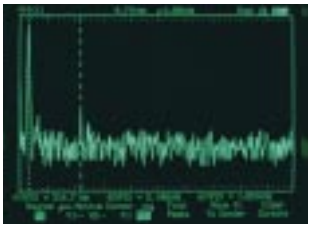
Potential problems

Letting students intentionally drop a speaker onto a lab bench could create some problems, especially with

Multiple bounces of the speaker on the hard surface of the lab bench produce a series of exponentially decaying ringing waveforms, one for each bounce. A deep memory scope such as the HP 54645A allows students to capture all the data for the event using only one drop.

Signal created by the resonance of the metal frame of the speaker is not visible, being swamped by the larger signal created by the resonance of the cone.

FFT of a bounce shows the second peak at 2.349 kHz created by the resonance of our speaker's metal frame.



Continued on page 10

HP's Education Program Web Site: A Wealth of FREE Instructional Aids

HP is constructing a new Educator's Corner area of the HP Test & Measurement website with a range of effective teaching tools created by academic and industry experts. These tools are designed to save you time by making it easier for your students to understand engineering and physical science concepts. Soon you will be able to visit the website to learn more about tools such as the Interactive Experiments, Interactive Tutorials, and Instrumentation System Emulators. Like many of the website's extensive information offerings, most of these teaching tools are offered to you for download at no cost. In the future, HP plans to offer the complete tool set on a CD-ROM.

Interactive Experiments

One type of powerful teaching aid that you can incorporate into your students' learning experience is the HP Interactive Experiment module. Available free from the HP website, these experiments teach students about rudimentary circuits and lab procedures. They include emulated lab equipment, a step-by-step tutorial for completing an experiment or lab class, hints for students who are having difficulty, and quizzes for students to complete at the end of each exercise.

Running an HP interactive experiment module on a PC and using a mouse, your students can connect leads and manipulate instrument controls, just as they would in class. This exposes students to test equipment sooner, allowing them to become familiar with instrument functionality before they attend their first hands-on lab class. They can even complete assignments on their own computer outside of the lab, learning at their own pace, while freeing up valuable lab time.

http://www.hp.com/info/college_lab101**

Interactive Tutorials

If a picture is worth a thousand words, an HP Interactive Tutorial is surely worth a million. A special type of application note, these electronic files use animation sequences to emphasize key concepts of the subject matter. Using their own PCs, students can manipulate the animations to see first-hand various cause-and-effect relationships, manipulating the variables in as many ways and as often as they need to grasp the concepts involved.

When students click on the illustration on page six of the application note on amplitude and frequency modulation, for example, they initiate an interactive, real-time movie. Now the students can vary the amount of modulation of an AM signal, and instantly see the corresponding variations in the frequency spectrum.

HP Interactive Tutorials are ideal for calculus and electrical engineering classes. By making it easier for students to understand how complex mathematical theories relate to scientific principles, these teaching aids help minimize the time you spend explaining and re-explaining difficult theoretical concepts.

Instrument System Emulator

The HP Instrument System Emulator is a free Windows®-based software package that provides on-screen emulations of basic test instruments. Designed by educators at Vanderbilt University in conjunction with Hewlett-Packard and Falcon Software*, the emulator presents a realistic view of the front panels of instruments in two common test setups: an HP 33120A function/arbitrary waveform generator used in conjunction with an HP 54600B digitizing oscilloscope, and an HP 33120A function/arbitrary waveform generator teamed with an HP 34401A 6½ digit digital multimeter.

No physical instrument connection is needed, so the HP Instrument System Emulator software helps you overcome the problem of having limited test equipment in the lab. Students can prepare for class by using the emulator to familiarize themselves with instrument operation. This will boost your teaching efficiency, since they will be able to focus their attention during the valuable lab time on completing the assignment, rather than on learning to operate the instruments.

See what's available

For a complete and updated listing of HP equipment, teaching tools, videos, software, and discounts available to educators, be sure to log onto the Educator's Corner website regularly. To explore HP's many other information offerings, be sure to explore the Test & Measurement website as well: http://www.tmo.hp.com

Windows is a U.S. registered trademark of Microsoft Corp.

** Falcon Software, 1 Hollis Street, Wellesley, MA 02181*

*** Note: This is a new website currently under construction. It is expected to be on line in April 1997*

Gain Greater Insight into Challenging Experiments with New Deep Memory Scope

Events of interest in many exciting and challenging educational laboratory experiments either take place over a long time span or are widely separated from the trigger event. Deep memory digitizing oscilloscopes allow students to acquire the requisite data, but traditionally have been difficult to use, and rather expensive for tight budgets. General-purpose digital oscilloscopes can be used for such experiments, but when they are, memory limitations force a choice between bandwidth and the amount of signal data that can be captured. This may require students to repeat steps in the experiment several times, adjusting the trigger setup as they search for elusive phenomenon, an iterative process that can be very frustrating.

The dual-channel, 100-MHz (200-MSa/s) HP 54645A is an easy-to-use, affordable, deep memory oscilloscope (1 million samples per channel) that's an ideal addition to any lab. It offers HP's exclusive MegaZoom signal capture technology that lets users see not only more signal history, but more details about each signal. Students can use the scope to capture long streams of full bandwidth signals, then easily scroll through the data looking for important details with the same intuitive controls that they use for other functions. (The speaker resonance lab experiment idea on page 3 illustrates how the HP 54645A can enhance the efficiency of a typical lab learning experience.)

Full featured

Despite its affordability via HP's educational discounts, the popular HP 54645A is a full featured, industrial grade, high-quality test instrument. In industry, engineers use this scope very effectively in diverse applications. They appreciate the way the straight-forward front panel controls and real-time display response help them stay focused on just two things: the circuit and the display. System designers find this scope particularly effective for the development of mixed signal systems containing both analog and digital information. This versatility means that you can rely on the rugged HP 54645A to handle a wide span of work, ranging from analog lab experiments to senior projects, and even to advanced research, while performing reliably in class after class, year after year.

For additional information on the HP 54645A oscilloscope, Check 11 on the reply card, or visit the Products area of the HP Test & Measurement website on the World Wide Web: http://www.tmo.hp.com

Also, see page 8 for details of a special promotion offer for educators that includes the HP 54645A.

After capturing long streams of wide-bandwidth data with the HP 54645A digital scope, students can use the rugged instrument's pan and zoom feature to scroll back through the data to find elusive phenomena.

Insights from first HP Education Advisory Council Meeting

To better understand the needs of those who teach our future engineers, a three-day Hewlett-Packard Education Advisory Council meeting was held last fall in San Francisco. HP invited twenty-seven engineering professors, teachers, and lab managers from universities to high schools in fifteen countries, to exchange ideas on the future of engineering and science laboratory education. Participants discussed how industry can partner with schools, hurdles in student acquisition and retention, hardware and software issues, future subjects to teach, the use of emulation, and leading-edge teaching processes for the lab.

The international scope of the HP Education Advisory Council meeting also produced some interesting information about education trends in various regions of the world. In Asia, for instance, there is a strong correlation between education and the standard of living, so Asian countries are making heavy investments in schooling. The long term result is that more Asian students will be staying in Asia for schooling, reducing the influx of foreign money to educational institutions in the United States and Europe.

At the conclusion of the meeting, the distinguished group of attendees reached consensus on other major trends:

* *Leading schools are making a concerted effort to emulate the real-life design experience, including ethical and economic tradeoffs, team experiences, time limits and open-ended assignments.*
* *Massive changes will befall the worldwide education system in the next 10-15 years. Technology will force new paradigms in asynchronous distance learning; schools will form international coalitions; much closer ties will develop with industry; and education will become more commercial. Even such venerated institutions as campus life and the tenure system are at risk.*
* *As distance learning techniques are perfected, students will gain the ability to custom design and choose both their courses and their instructors.*
* *Schools are having a hard time keeping up with the demand for network engineers and those who understand RF communications and lightwave. This is made doubly hard by the schools' small budgets.*
* *The "23-minute society" created by television has spawned students with short attention spans who have a hard time staying focused on a problem long enough to solve a complex assignment. The dilemma is that if we make the labs too easy, students won't learn, but when we make the lab work more difficult, the students balk.*
* *Today's students often lack experience in "tinkering." This deficit increases the importance of hands-on learning strategies. A mix of emulation and hands-on experience is proving to be an efficient way to teach labs. Still, there is simply no substitute for asking students to solve challenging problems using instrumentation that is similar to the equipment they will use in their profession.*

In the U.S. and Europe, where advanced telecommunication and computer network infrastructures now exist, distance learning will change the face of education and will create a new export business for educators. By reducing the time that a student spends on campus, distance learning will help alleviate the rising cost of higher education. And allowing students to choose their courses and instructors may benefit skilled and innovative educators. Interestingly, attendees from Europe pointed out that many of the changes being made to revitalize U.S. engineering schools, such as team projects and hands-on education, have long been common practice in their home countries.

Visit HP's Educator's Corner Website ...

for up-to-date Engineering Educator information:

http://www.hp.com/info/college_lab101

Note: This is a new website currently under construction. It is expected to be on line in April 1997

As a result of the highly successful meeting, HP has designed a number of teaching tools, including lecture tools, interactive experiments and application notes that are now available at HP's Educator's Corner website. We are also addressing the educators' desire for information on a typical day in the life of an engineer, more corporate/educational institution alliances with leading companies such as HP and, of course, grants or special pricing on the equipment needed to teach students more effectively.

T&M Lab Equipment Update

Get four channels for the price of two

For a limited time, educators can take advantage of a special offer from Hewlett-Packard. When you buy an HP 54600-Series oscilloscope* and two basic test instruments**, you are entitled to receive the next higher grade oscilloscope at no extra charge.

For example: Buy an HP 54600B 100-MHz, 2-channel digitizing oscilloscope plus two each HP 34401A digital multimeters and you can substitute the 150 MHz, 4-channel HP 54602B scope for the HP 54600B, at the price of the HP 54600B. And your educational discount still applies.

The list of eligible products is:

***Oscilloscopes:**

HP 54603B
60 MHz, 2-ch digitizing oscilloscope

HP 54600B
100 MHz, 2-ch digitizing oscilloscope

HP 54602B
150 MHz, 4-ch digitizing oscilloscope

HP 54645A
100 MHz, 2-ch digitizing oscilloscope with MegaZoom deep memory

****Basic test instruments**

HP 34401A
6½-digit DMM with HP-IB/RS-232

HP 33120A
Function/arbitrary waveform generator with HP-IB/RS-232

HP E3631A
Triple-output, 80W power supply with HP-IB/RS-232

Buy any **two** of these:

HP 34401A 6½ digit DMM

HP 33120A Function/Arb Generator

HP E3631A Triple Output Power Supply

\+ Any digitizing **scope**

- HP 54603B 60-MHz, 2-ch
- HP 54600B 100-MHz, 2-ch
- HP 54602B 150-MHz, 4-ch

And we'll substitute a higher performance **scope** at **no** extra **cost**

- HP 54600B 100-MHz, 2-ch
- HP 54602B 150-MHz, 4-ch
- HP 54645A 100-MHz, 2-ch with MegaZoom deep memory

6½ digit DMM saves you money

For less than the cost of some 5½ digit multimeters, the HP 34401A, the world's most popular 6½ digit DMM, gives you the capabilities you need for advanced student lab assignments. Demonstrate Op. Ampdrift, or look at small signals with ease. Order HP's H1301A DMM training video and turn your Teaching Assistant into a DMM expert.. The DMM has 11 measurement functions and internal storage for 512 readings. The DMM has HP-IB (IEEE-488) and RS-232 interfaces as standard. For more information, check 2 on the reply card, or use the literature request form of HP's Educator's Corner website*:
http://www.hp.com/info/college_lab101

Function/arbitrary waveform generator

Use the economical HP 33120A synthesized function/arbitrary waveform generator to demonstrate heartbeats, noise, sinc functions, or generate something as simple as a sine wave. It produces signals up to 15 MHz using direct digital synthesis, and also creates arbitrary waveforms with a built-in 12-bit, 40 MSa/s, 16K-deep arbitrary waveform generator. The fully-programmable signal source has modulation and sweep capabilities built-in. Optional BenchLink/Arb software simplifies composing and modifying the generator's waveforms on a PC before downloading them to the HP 33120A. For more information, check 3 on the reply card, or use the website's literature request form.*

Triple-output dc supply is programmable

The highly versatile HP E3631A triple-output dc power supply is ideal for powering a wide range of student lab experiments with two 25 V, 1 A outputs and one 6 V, 5 A output. Meters display both voltage and current with four digits of resolution. A traditional knob changes settings quickly and precisely. All outputs are protected against overload and short-circuit damage *(handy for sophomore labs!)*. The HP E3631A can be programmed from a PC through either HP-IB or RS-232. For more information, check 4 on the reply card, or use the website's literature request form.*

**Note: This is a new website currently under construction. It is expected to be on line in April 1997*

Literature

The following literature is now available:

The following literature is now available:

Engineering Educator's Test & Measurement Tool Kit, an eight-page brochure, describes videos, software, training kits, and computer based learning products, as well as books, application notes, catalogs, posters, and brochures that can make it easier for you to teach the fundamentals of engineering. Many of the tools and teaching aids listed, from HP or third-party suppliers, are available free to educators.

Check 1 on the reply card, or contact your HP call center or HP salesperson for more information.

HP's 1997 Test & Measurement Catalog, the updated edition of the industry's most comprehensive test and measurement reference source, is an invaluable tool for researching, planning, budgeting, and purchasing just the right HP products and services to meet your laboratory's test needs. The hard cover catalog lets you quickly examine and compare an unmatched range of instruments, systems, software, and accessories. Find the detailed data you're looking for with speed and convenience. Check 7 on the reply card, or request a copy through the HP TMO website:
http://www.tmo.hp.com

A complete listing of the equipment, teaching tools, videos, software, and discounts available to educators is also available at the Educator's Corner website.*
http://www.hp.com/info/college_lab101

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Measuring Mechanical Resonances of an Electromagnetic Speaker

Continued from page 4

overzealous individuals. The basic idea for this experiment was "borrowed" from an experiment created by Professor Walter Banzhaf of the University of Hartford, Hartford, Connecticut[1], which uses a different approach to teach the same principles of physics. He asks the students to drop a penny on the speaker cone, and analyze the signals produced by the multiple bounces of the coin. With Dr. Banzhaf's experiment, however, no signal is produced by the metallic frame resonance, because the frame hasn't been struck. To generate that resonance for analysis, you could add a second part to the lab procedure whereby the students drop the penny on the speaker frame instead of the cone.

Additional information is available on the World Wide Web* at :

http://www.hp.com/info/college_lab101

References/additional study

1. Banzhaf, Dr. Walter, "Integration and Applications of Digitizing Oscilloscopes in a BSETT Program," 1994 ASEE Annual Conference Proceedings, p. 1168.

2. Hewlett-Packard's interactive application note, 150-1, Spectrum Analysis: Amplitude and Frequency Modulation, is available in the Application Notes section of the HP/Test & Measurement web site (http://www.hp.tmo.com) for download to your students' computers. This application note explains the measurement of amplitude and frequency modulated signals using a spectrum analyzer, and presents the basic theory behind AM and FM modulation, including time and frequency domain representations. One of the four signal animations in this note allows the student to vary the degree of modulation of an AM signal and instantly see the corresponding variations in the frequency spectrum of that signal.

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Reducing Dropout Rates

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yet flexible, system for providing timely tutorial assistance. To address the issue of "wrong first choice," Drexel's E4 team decided, among other things, to emphasize that the freshmen were "engineers in training" from their first day at the university, and to maximize the multiple benefits that students could obtain from exciting, stimulating, hands-on lab work.

Immediate exposure

First-year students receive an immediate exposure to a knowledge base that Drexel's faculty believes will comprise essential common elements for successful practice in the 21st century. The core freshman- and sophomore-year experience stresses the interdisciplinary mathematical and scientific foundations of engineering, the transcendent role of the computer, and the pivotal role of experimentation. The curriculum underscores "design" as the defining constant and universal element of the engineering profession. Finally, the educational experience underscores the imperatives for developing superior personal communications and teamwork skills, as well as a culture for life-long study for continued professional success.

The program recognizes that students learn best when they have a support group and are actively involved in the subjects they're studying. The faculty team works quickly to build an esprit de corps, a "can-do," sharing, and caring attitude among the entering class. They organize students into teams competing to develop solutions for practical problem-solving laboratory projects.

The lab assignments are engineering-type challenges that are readily achievable with appropriate effort. They present freshman students with problems that afford considerable latitude for experimentation and creativity and that give participants a strong sense of accomplishment when successfully mastered. Other educational goals include team-building, the essential elements of scientific problem solving and project management, and the development of interpersonal skills.

Typical of these team projects is the assignment to build, using a standard kit of parts, a bridge of a defined span that must handle a designated minimum load. Upon completion, the bridges designed and constructed by the various student teams are first subjected to the minimum load for performance verification, then tested to destruction to determine the maximum strength-to-weight ratio of the competing designs. Competition is intense and numerous designs exceed the minimum load by a factor of ten. Such challenging and exciting lab assignments produce immediate and long-lasting results in terms of positive attitudes toward engineering and the educational process at Drexel.

Results extremely positive

Results of the new Drexel program have been extremely positive. The achievements of students in a wide variety of performance tests and the execution of their projects indicate that most students developed excellent and, in many cases, truly outstanding levels of communications, laboratory, and computer skills. They also had, on average, 30 percent higher graduation rates, 20 percent higher progress rates, and 25 percent higher and grade point averages than their counterparts in the traditional program. Student personal responses are also quite positive. In addition to their academic achievements, their written commentaries indicate that many begin to sense, even in the freshman year, that the practice of the engineering profession will be personally exciting, rewarding, and enjoyable.

Other measures of the success of Drexel's E4 program include the widespread recognition and numerous awards it has received from the American Society of Engineering Education (ASEE), The National Research Council (NRC), The National Academy of Engineering (NAC), the Institute of Electrical and Electronic Engineers (IEEE) and the American Society of Mechanical Engineers (ASME). In 1990, the Accrediting Board for Engineering and Technology (ABET) presented the program its inaugural "Award for Educational Innovation." The program was also honored by installation in the Smithsonian Institution's permanent research collection on technology and society in 1996. But more importantly, most E4 students (90 percent) have cited their professors as the factor they most liked about their educational experience , compared to only 14 percent of the students in the national survey.

Surveys and private interviews with participating faculty by an external evaluator indicated that the overwhelming majority felt they were enriched by this new professional experience. The program has resulted in the development of five new textbooks. More than fifty professional publications and formal presentations at professional and scholarly meetings have been supplemented by a large number of symposia and seminars.

Additional information on Drexel's E4 program is available on the World Wide Web* at :

http://www.hp.com/info/college_lab101

**Note: This is a new website currently under construction. It is expected to be online in April 1997.*

References and acknowledgments listed on page 12

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