Engineering EDUCATOR

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

VOLUME 1, NUMBER 2
FALL 1997

INSIGHTS

Things to Come

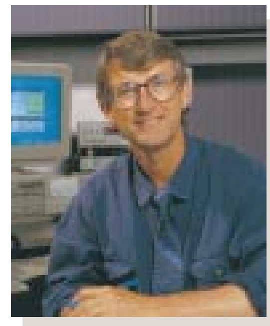
Marsh Faber, Editor

A clear day. Calm seas. Your husband has the sailboat's helm, so you decide to catch up on your microcontroller class. You go below and grab your computer, a device resembling an old-fashioned PC — except that it's got 5 Gbyte of RAM. When you log on via satellite, the system automatically deducts a small fee from your quickly dwindling bank account: some for the school and some for the satellite provider. Downloading the 45-minute multimedia lesson takes about 20 seconds.

You do the interactive lesson and submit the homework. A polite reply tells you of some flaws and coaches you through correcting your mistakes. You must re-submit for a perfect grade and predict what you think the circuit will do before you're allowed to set up the on-line experiment. Via satellite, the instruments respond, and you see the results live on screen.

It's asynchronous learning, and it's coming soon to a theatre near you.

No, I don't see satellite systems replacing campuses. Young people still need a place to grow up and parents need a place to send them in order to preserve household sanity. And I don't see simulation replacing hands-on lab experience. Admittedly, changes are coming — like the near-Gigabit speeds from the Gates-McCaw "Internet in the Sky" and Motorola's "Celestri" systems — that will dramatically affect our ability to disseminate large quantities of information. But before we get too hung up on *things* used to teach, let's not forget that we — especially engineers — rarely use what we know about *people* and especially about the way they learn.



For a quick refresher in learning theory, try our feature article. The Integrated Teaching and Learning Lab at the University of Colorado is one of the finer teaching environments on the planet. They integrate learning theory into the engineering curriculum, and add excitement as a bonus. True, it's a well-funded program, but there are a wealth of ideas in the CU program that cost nothing to implement. Instead of simply computer-based instruction, CU is creating human-based education.

Marsh Faber
Education Program Manager
Electronic Measurements Division

IN THIS ISSUE

HEWLETT PACKARD

Share Your Thoughts

This newsletter and the 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.

Spreading the Word

Dear Marsh,

I just found the HP Educator's Corner Website (thanks to your Engineering Educator, Vol.1, Number 1), and thought I'd pass along the site URL to about 1000 members of the Engineering Technology Division List Server at Oregon Institute of Technology. They come from all over the country, and I'm sure many will be interested in viewing the fine stuff you have made available. Good job! Well done!

Professor Wally Banzhaf
University of Hartford
banzhaf@uhavax.hartford.edu

Reply:

Professor Banzhaf,

Thanks for your MAJOR contribution on the Educator's Corner Website. Without a doubt, your innovative, simple and elegant experiments will be used by a number of schools around the world.

Marsh Faber

Website Feedback

This is a fabulous thing you are doing for educators, and I am very impressed with the applets you've done (or perhaps they were written by authors?). I maintain a site that lists educational software for engineering and science, (http://www.pws.com/canit.html) and I will be sure to list your site. Please let me know if there is any way we could help.

Leslie Bondaryk
Manager of Technology Development
PWS Publishing Company
leslie_bondaryk@pws.com

Reply:

Leslie,

Thanks for the kind words. The applets were based on first-year instructional material sent in by several educators. We combined the material and wrote our own animated simulations. The simulation text and ideas were largely done by co-op students from the University of Denver under the direction of Professor John Getty, and the animations were done by HP in conjunction with Viewmark, an electronic media company. By the way, I visited your site and found it to be quite useful as a clearinghouse for educators who run engineering labs. Nice work yourself!

Marsh Faber

Math Basics Needed

Marsh,

I liked the first issue of the Engineering Educator. Since I've begun working to build new educational materials, and am seeking funding where coalitions with companies is a benefit to the applying party, I thought I'd try out the [HP Educator's Corner] Website. It seemed to me that there's a serious mismatch between the level of material in your application notes and students' knowledge. Many, and that includes computer science students, just don't have the kind of basics, nor the wealth of experience electrical engineers have in working mathematically, to benefit from what you have there.

Since January I've developed a course-oriented website: the URL is http://www.cs.ucla.edu/csd-lanai/fweb/cs190. I've put many math-education items into the site. Although the overall emphasis is on concepts and practices in design, my own interests in mathematics, particularly in its relationship to computer science, drove a lot of work with students, and we've built up quite a few visual items. I'd value any thoughts, comments, suggestions, or pointers.

Allen Klinger
Professor, UCLA
klinger@cs.ucla.edu

Reply:

Professor Klinger,

The material on the Educator's Corner Website was designed specifically for university engineering students and faculty, not for high school students or students with other majors.

I applaud your efforts at raising the math competency of engineering and computer science students. HP is addressing the issue at a more fundamental level, through a program called E-Mail Mentor. In this extensive program, we pair one HP employee with one student in 5th through 12th grades to encourage students to get involved with and enjoy math and science. While we don't extend the program to the university level, we certainly encourage anyone else to adopt the formula that can be viewed at: http://external.mentor.hp.com.

Marsh Faber

Engineering Students Create What They Dream

Lawrence E. Carlson & Jacquelyn F. Sullivan,
Co-Directors of the University of Colorado
Integrated Teaching and Learning Lab

The College of Engineering and Applied Science at the University of Colorado at Boulder is in the fifth year of a bold, College-wide program that models the real world of engineering where skills in communication, teamwork, and leadership, as well as the ability and self-confidence to define and solve open-ended problems, are demanded. A team of faculty and students defined and realized an ambitious vision for undergraduate engineering education reform:

"…to pioneer a multidisciplinary learning environment that integrates engineering theory with practice and promotes creative, team-oriented problem-solving skills."

The Integrated Teaching and Learning (ITL) Program integrates hands-on learning experiences throughout all four years and engages students in the design process from their first year. Cutting across all departments, the new curriculum vision is supported by a new hands-on learning facility. The ITL Laboratory, officially dedicated in April, 1997, integrates leading-edge Hewlett-Packard technology with the understanding and confidence borne of hands-on learning. The ITL team won legislative approval of the project, as well as state funding for one third of the cost. In partnership with our students, the rest of the $17M ITL Program funding was raised by engaging alumni, corporations and foundations sharing in our vision.

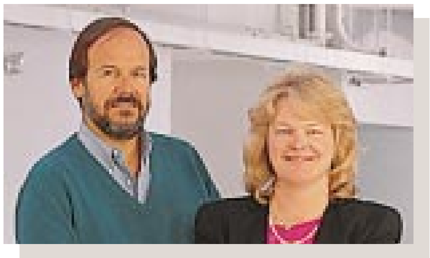
Lab stations equipped with HP computers and test and measurement equipment provide student teams with powerful analysis and data acquisition capabilities.

A Curriculum-Driven Laboratory

To support curriculum reform, the 34,400 sq. ft. Integrated Teaching and Learning Laboratory was created: a learning environment designed from the ground-up to support hands-on learning. The facility features first-year design studios, an active learning center, a computer simulation laboratory, an extensive computer network that integrates all the experimental equipment throughout two large laboratory plazas, capstone design studios to showcase student projects, group work areas to support student teams, shops where students turn their dreams into reality and interactive science-based kinetic sculpture galleries. The ITL Laboratory is equipped with state-of-the-art Hewlett-Packard instrumentation, computers and networking capability.

Learning Engineering by Doing

In a common first-year design course, students work in interdisciplinary teams to design, build and test real products for real customers. While experiencing the design-and-build



process first-hand, students define customer needs, sharpen their presentation skills, manage their time and budget their own money. Students in some sections develop assistive technology devices to help people in the community with disabilities. For example, an HP executive with a hearing deficit now modulates his speaking volume thanks to visual feedback from a sound level meter designed into his wall clock. Students in other sections build interactive exhibits to help middle school students learn about science and technology, like a desktop tornado in a box. Structured team dynamics activities and workshops help students understand the nature of group work, mirroring the real world and providing a strong foundation for lifelong learning skills. Preliminary retention figures indicate that a remarkably higher percentage of students who take this course remain in engineering into their third year.

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Turkish Engineering School Creating a Bridge to the Future

Perched at the intersection of three continents, Turkey acts as a bridge between East and West, between radically differing cultures and lifestyles. Nowhere is that more evident than at one of the country's largest universities, the Middle East Technical University in Ankara, where students from Europe, the Middle East, and Central Asia — from as many as 50 different countries — gather to learn.

METU-TECHnopolis

Now the university is capitalizing on its extensive experience bridging cultural diversity with an ambitious and innovative complex called the METU-TECHnopolis, a technology park that's designed to bridge the gaps between technology and nature, and between industry and academia. The on-campus complex consists of a science park, a business park and a residential area, all tied together by a large green belt that hosts a variety of cultural, artistic and recreational activities.

The university wants to populate the science park with international and local corporations involved in high-tech research and development in fields like biotechnology, robotics, materials sciences and microelectronics, and information-based activities such as software development and data processing.

But what would attract an international company to build a facility at the METU-TECH complex? Close links with the university, "intensely green" environmental features and the existence of an advanced telecommunications infrastructure (including direct satellite internet access), are three good reasons for companies to consider the investment, according to Dr. Tayfun Akin, assistant professor in the Department of Electrical and Electronics Engineering.

Although METU-TECH is still in its infancy, ten Turkish and two international companies have expressed interest in the project, and construction has begun on the first buildings.

Preparing Students for High-Tech Jobs

Akin believes close ties to companies in the new technology park will help him prepare students for the changing high-tech work environment they will face when they graduate. "Right now, we provide a really good theory-oriented education," said Akin. "When we are working more closely with industry, we should be able to offer students more hands-on experience. I am convinced that this is a valuable tool for motivating and training students."

Dr. Akin and a colleague, Dr. Cengiz Besikci, assistant chairman of the Department of Electrical and Electronic Engineering at METU, recently traveled to the United States to discuss pedagogical issues with US engineering educators and to gather innovative ideas for possible implementation in Turkey. The pair reached the conclusion that their university shares many similarities with engineering colleges on the other side of the globe.

Perhaps they noticed that bridge building is a popular subject.

For more information about METU and the METU-TECHnopolis, see http://www.metutech.metu.edu.tr.

On a recent trip to the United States, METU Assistant Professors Dr. Tayfun Akin, left, and Dr. Cengiz Besikci toured the University of Colorado Integrated Teaching and Learning Lab (see story on page 3). Here, the two experiment with one of the many kinetic sculptures in the new engineering education facility.

Switching, Thermals and Other Topics

Marsh Faber
Hewlett Packard

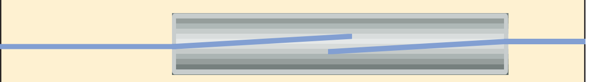

Figure 1: Reed switch — "kovar" (ferrous) metal leads; glass frit seal between metal and glass body.

Objective:

To show how something as simple as a reed switch can give clues to real-life design issues and tradeoffs.

Equipment:

- HP 33120A Synthesized Function/ Arbitrary Waveform Generator
- HP 54600B 100 MHz Digital Oscilloscope
- HP E3631A Programmable Power Supply
- HP 34401A 6½ Digit DMM
- Simple "form A" reed switch with magnet or magnetic coil to activate the reed switch

Introduction:

We often see labs designed around a complex device-under-test, but we can learn a lot from a very simple electronic device. One such device is the reed relay, composed of a reed switch and a driving coil. A "form A" (single-pole, single-throw) reed switch is a simple device, consisting of a glass vial that encases two ferrous switching elements.

When driven by a magnetic field, the two ferrous elements are drawn together, closing the circuit. Obviously, the magnetic field can be generated either by a permanent magnet or by an electromagnet. When the electromagnet is used, the combination is called a "reed relay."

Metal Migration

Reed relays are fast for mechanical devices — they can close in milliseconds — but they only have a small contact area, so contact ratings tend to be minimal.

Question: The dc rating of a reed switch is much less than its ac rating. Why do you think this is so?

When switching dc current, the contact material migrates from one contact to the other, creating a pit on one side and a "hill" on the other. With ac current, the migration tends to take place in both directions, giving longer switch life.

This contact pitting increases the "on" resistance and shortens relay life. If you're switching large currents with any relay, it's best to use a "snubber" network — a series RC network

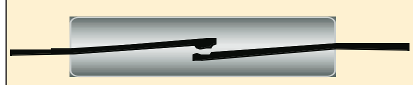

Figure 2: Pitted contacts due to dc switching

placed in parallel with the contacts. Of course, the snubber network won't work in all cases. Sometimes the circuit parameters prohibit any kind of impedance from being placed around the switch.

"Why do I care? After all, I don't use reed relays much." Well, maybe you do. They're found in portable phones, VCRs, TV sets, remote control toys, instruments, video games, PCs, motors, cars and just about anywhere electronics are used.

Contact Resistance

Experiment: Let's hook up a relay and look at some design constraints. First, let's just turn on the switch and measure its resistance. For that you need a permanent magnet or a coil and a power supply. (See Figure 3.)

Set the power supply output to zero. This is important! (You don't want to burn out the coil before you begin the experiment.) Connect the switch contacts to the DMM, and set the HP 34401A to Autorange, 6 digits. The DMM should show Overload (open

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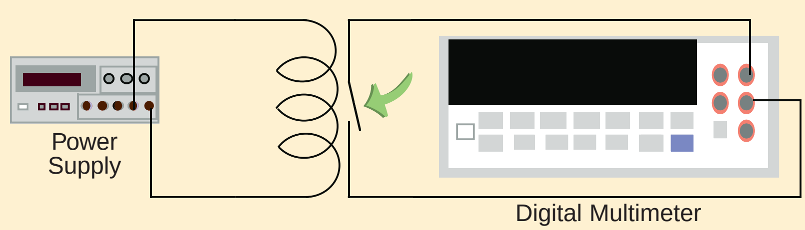


Figure 3: Measuring contact resistance

Switching, Thermals, and Other Topics

Continued from page 5

circuit). Now *slowly* increase the power supply voltage until the DMM suddenly shows a reading, typically below 1 ohm. Record the resistance.

Without exceeding the maximum voltage specification on the relay coil, slowly increase the drive voltage and read the contact resistance. Does it change?

Reduce the drive voltage until you can see exactly at what voltage the switch opens. Record that voltage. Now increase the voltage, *slowly*, until it turns on again. You might have to do this a few times to get the exact numbers. Is the turn-on voltage the same as the turn-off voltage? Why or why not?

BRAINSTORM: If you were to slowly ramp up the power supply, what would happen if the turn-on voltage and the turn-off voltage were exactly the same?

Unwanted Thermal EMF

Exercise: Measure the contact voltage by switching the HP 34401A digital multimeter function to Vdc, Autorange, 6 Digits. This will give you 1 microvolt of resolution. Is the voltage zero? Is that what you expected? Hold *one* end of the relay with your hand, at the junction of the kovar lead and the copper lead.

Does the DMM reading change? How much? Now move your hand to the other end of the switch and try it again. Does the reading change? What's happening here?

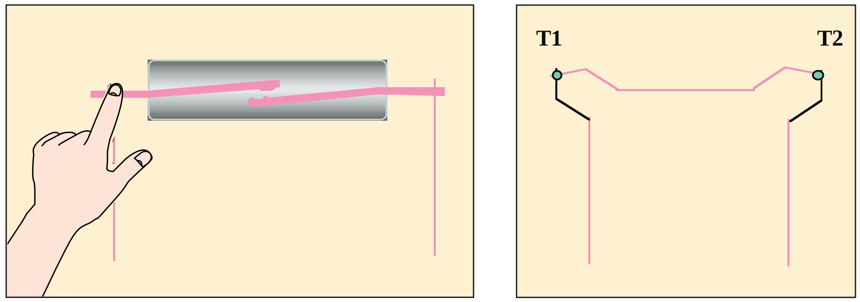


Figure 4: Thermal voltages produced by kovar/copper junction. The circuit is equivalent to two thermocouples in series. V thermal is proportional to T1-T2. To eliminate the thermal voltage, force T1 to equal T2.

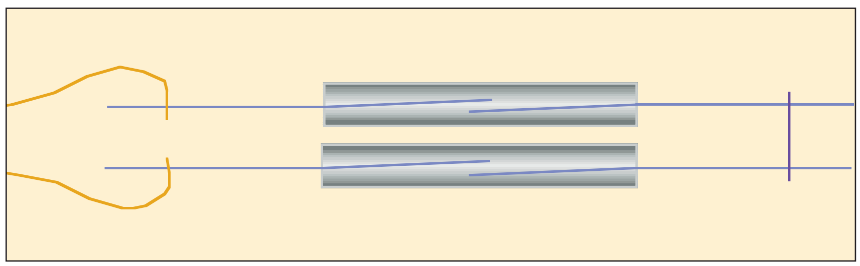


Figure 5: Welded kovar leads minimize thermals; Cu/kovar junctions are physically close together so that their temperatures are nearly the same.

The "kovar" wire must be ferrous in order for the reed switch to operate under a magnetic field. But the wire to the DMM is copper, and the two metals combine to form a kovar/copper thermocouple. That means unwanted offsets — up to hundreds of microvolts — will occur unless the two ends are at *exactly* the same temperature.

BRAINSTORM: How could we get rid of these thermal voltages?

One idea: Two switches arranged differentially: In Figure 5, the idea is to move the junctions close together so the thermal gradient across the junctions is minimized. We are relying upon the switch voltages to cancel differentially. This is one of the great maxims of engineering: whenever possible, *always* use a differential measurement.

BRAINSTORM: Find some other techniques to minimize the thermocouple effect.

BRAINSTORM: Give examples of other differential measurements.

Strain Relief

If you must bend the reed switch leads, you need to utilize a stress-relieving technique. In order to bend that wire without unknowingly cracking the glass, it is imperative to use a clamping device on the wire, and not stress the glass directly. See Figure 6.

The two-plier method shown in Figure 6 may not be the best process to en-sure stress-free bending of the switch, but it is certainly better than grabbing the relay with the hand and bending the switch lead against the body of the glass case.

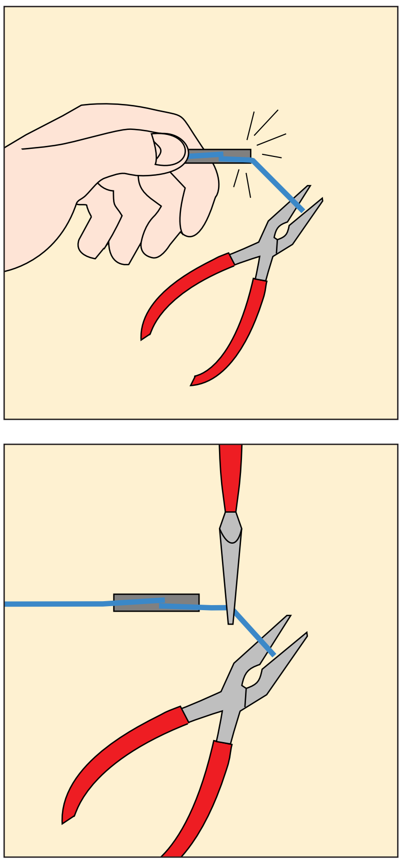


Figure 6: The use of a clamp to bend the switch lead minimizes strain on the relay.

***BRAINSTORM:* What other applications require strain relief? Think about aircraft, bridges, cables and moving parts, and about several engineering disciplines other than your own.**

***BRAINSTORM:* What other problem do you create when you hold the reed switch with your bare hand?**

Thermal Expansion and Reliability

Many reed switches are encapsulated in a glass tube. Why do you think this is so? The interface between the glass tube and the switch is mechanically weak. When the entire switch is heated, the glass can expand at a different rate from that of the metal leads, creating a great deal of physical stress on the glass/metal interface and resulting in a catastrophic failure, or simply a leaky glass tube that invites corrosion.

***BRAINSTORM:* Where else is thermal expansion, or differences in thermal expansion, a problem?**

Contact Bounce

One early use of reed switches was in PC keyboards. Magnets in the keys activated reed switches. But any bouncing of the switch contacts causes multiple signals to be sent to the decoder circuit, so a "de-bouncing" circuit was implemented. This situation is well covered in the experiment from Dr. Walter Banzhaf of the University of Hartford (see the HP Educator's Corner Website at http://www.hp.com/info/college_lab101).

***BRAINSTORM:* Where would YOU use a reed switch?**

Tradeoffs

The discipline of engineering is a study in decision making. We are constantly asked to trade one benefit for another, rarely getting both at the same time. As an example, just look at a few of the tradeoffs we could be asked to make on the simple reed switch:

Cost vs. speed, size, vendor's delivery time

Voltage limit vs. current carrying capacity

Speed vs. power dissipation

Thermal emf. vs. ferrous content of switch elements

Contact resistance vs. coil current, temperature, contact size

Delay time vs. coil current, IC driver protection

Breakdown voltage vs. size

Coil-to-switch capacitance vs. cost of guard shield

How many other tradeoffs can you think of?

Conclusions

The reed switch, though an extremely simple device, can be used to demonstrate a number of engineering tradeoffs that span electrical, mechanical and chemical disciplines. In fact, the many questions posed in the above exercises barely scratch the surface of the lowly reed switch.

Educator's Corner CD-ROM Packed with Useful Resources

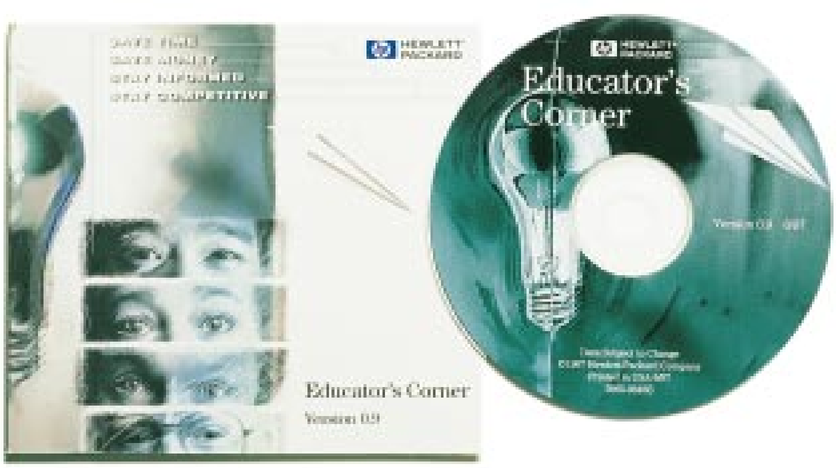
Imagine getting a gift box full of tools designed to make your day more productive and rewarding. Now let your imagination really soar and imagine that the gift box is free to engineering educators. It's not just a pleasant day dream, it's the new Educator's Corner CD-ROM from HP.

The CD is packed with many of the same resources you'll find on the Educator's Corner Website (http://www.hp.com/info/college_lab101), designed to save you time (by providing you with real teaching aids you can use today in the classroom), save you money (by showing you the latest values that will help you keep your lab up to date) and help you stay informed. Why'd we bother publishing a CD if the material is already available on the web? Because we know that time is a precious commodity among engineering educators. With the content available locally, you'll have faster, more convenient access to all the goodies, including application notes, tutorials, slide presentations, an encyclopedia of lab experiments, reference tools and other materials on how to use electronic test equipment.

If you've already got a browser installed on your computer, the CD connects to it to give you a familiar interface for surfing the CD's content. Otherwise, you can use the Internet Explorer that comes on the CD. If you're connected to the internet, you can click on a multitude of live links embedded in the CD's content to access late-breaking information directly from the web. You'll also find a handy search engine on the CD to help you find the material you need quickly and easily.

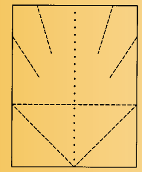
To get your free copy of the Educator's Corner CD-ROM, use the reply card stapled in the middle of this newsletter.

Visit the Educator's Corner Website today!
http://www.hp.com/info/college_lab101

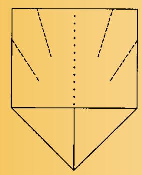


Soar to New Heights!

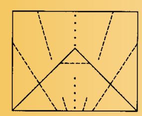
Here's the first of a series of paper airplanes we'll be including in issues of this newsletter. Fly them, collect them, combine several to create an unusual mobile or challenge your students to create ones with a longer glide distance. Most of all, have fun!



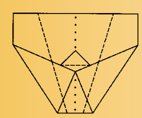
1. Crease along centerline, fold 7, and reopen.



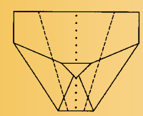
2. Fold along lines 1 and 2.



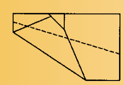
3. Fold along line 3.



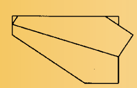
4. Fold in flaps on lines 4 and 5.



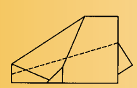
5. Fold point down on line 6.



6. Rotate plane and fold in half along its centerline, fold 7.

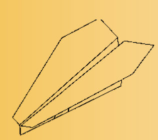


7. Fold wing up along line 8.



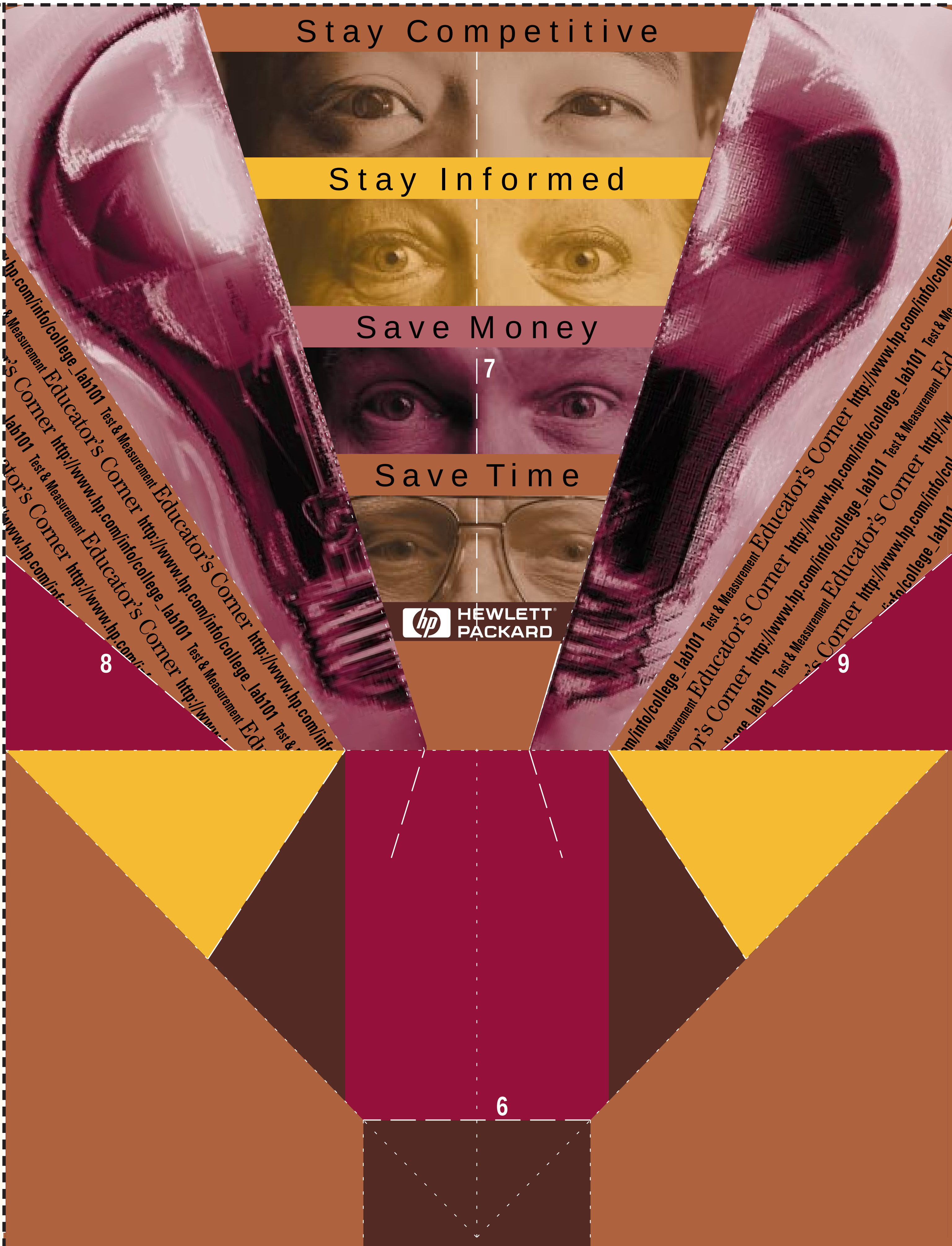
8. Flip plane over.

9. Fold wing down along line 9.



Bend elevators up slightly for best flight.

Cut here. Fold in on dashed lines; fold away on dotted lines.



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Engineering Students Create What They Dream

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Breaking Down Departmental Boundaries

The ITL team took an interdisciplinary approach to transcend traditional departmental boundaries by forming eight focus area teams, each of which includes topics taught in multiple disciplines: measurement and instrumentation, electronics and microprocessors, fluid mechanics, heat transfer, structures and materials manufacturing, controls, and environmental.

The teams developed over 35 experimental laboratory modules to augment sophomore and junior courses, making theoretical concepts come alive. The “mysterious” mathematics of Fast Fourier Transforms are more compelling to students when an electric guitar generates the signal. Modules are key curricular components of new interdisciplinary focus courses, two of which are now offered in the ITL Laboratory. Simple “hands-on homework” experiments using basic household supplies put engineering science principles into real-world context. Keeping honey on a spoon illustrates the rate dependence of fluid viscosity more effectively than a “chalk and talk” lecture alone could ever do.

A Living Laboratory

Unlike any other educational facility in the world, the ITL Laboratory itself functions as a living laboratory. The color-coded mechanical room reveals what makes a building “tick”. More than 200 sensors integrated into the building continuously measure a wide array of data in including structural loading, temperatures, performance of the climate control system, electrical system performance, etc. For example, the temperature measured every inch through four solid concrete walls serves as an in situ heat conduction experiment. Monitored every five minutes, the data are archived and will be accessible on the Internet as a technology and building systems resource for all engineering institutions. Learners of all ages follow a self-guided tour of the many exposed engineering systems, featuring interpretive signs, to see first-hand a variety of building systems.

Bringing Art into Engineering

An exciting and educational feature of the ITL Laboratory is the collection of interactive kinetic sculptures. Visually intriguing, all of the exhibits provide deeper quantitative opportunities for engineering students. For example, “Pythagorean Fantasy” by New York artist George Rhoads features colorful balls rolling throughout a variety of tracks doing loop-the-loops, ballistic trajectories and other convolutions. Instrumentation allows students to quantitatively compare dynamics theory with observed reality, while as a side benefit learning about instrumentation along the way.

At CU, first-year engineering students design and build assistive devices for disabled clients. This gearing system, created by a four-student team, allows its delighted owner to propel his own wheelchair by pushing down on the lap bar.

The Next Steps

Winston Churchill observed that “first we shape our buildings, then our buildings shape us.” With the ITL Laboratory now open, we reach an exciting milestone. The fruits of a dedicated team’s five years’ labor become accessible to all undergraduate students and faculty in the College — shaping their learning and our future in new and exciting ways. We are only limited by our imagination.

For details about the ITL Laboratory, visit the website: http://itl.colorado.edu

HP VEE Lets Inexperienced Students Automate Tests Fast

The current trend is for universities to introduce hands-on engineering projects to first- and second-year students. One challenge of this approach is structuring real-life design experiences for students who may not have necessary math and programming skills.

HP VEE, an easy-to-learn, PC-based visual programming language, can help. With HP VEE students can create test and measurement programs for simulation, modeling and analysis by clicking and dragging icons into place, and entering parameters and formulas in dialogue boxes. Because it's so easy to use, students can focus on the course material, instead of getting bogged down in programming problems.

As a teaching tool, HP VEE can make your life easier, too. Version 4.0 provides the features you need to effectively demonstrate engineering and scientific principles, like RF communication and lightwave technology. Use it in the lab, too, to create computer-controlled labs that are easy to build, replicate and maintain.

An easy-to-use instrument manager, point-and-click instrument driver control and direct I/O contribute to HP VEE's "best in class" status.

HP VEE for Instruction

Teaching the Physics of Fiber Optics at Munich's Polytechnic University

Students get acquainted with the physics of fiber optics in the optoelectronics laboratory at the Polytechnical University (Fachhochschule) in Munich, Germany. In the lab, students use a test assembly that determines the spectral damping and cut-off wavelength of monomode fiber optics, as well as PC-based controllers and HP VEE to simplify and automate the difficult tasks of instrument control and automation.

A test run consists of scanning a defined spectral range. At each wavelength that is fed into the fiber, a light-sensitive diode measures the relative intensity of the light. An HP VEE program controls a monochromator and a lock-in amplifier, automatically performs the required tests (including calibration), and analyzes the data.

"The visual environment of HP VEE assures a high degree of productivity, even with students who are unfamiliar with test and measurement practices," said Dr. Albert Gleissner.

HP VEE for University Research

University of Illinois Automates Study of Ambient Aerosol Particles

As part of a long-term global research program, the University of Illinois at Urbana-Champaign (UIUC) is studying ambient aerosols that can potentially counteract global warming caused by greenhouse gases. The research team is using a "humidograph" for studying the optical properties of atmospheric ambient aerosols to better understand the chemistry and physics of the atmosphere.

The humidograph samples ambient air and uses temperature and relative humidity control for studying light scattered by atmospheric particles. For a solid data acquisition process, the team automated the humidograph by interfacing HP VXI hardware and HP VEE software with a 486-based PC to run continuous tests."Automating the humidograph improves our confidence, reliability, and ability for continuous sampling for weeks to months at a time for characterization of aerosol properties at each site," says Dr. Mark Rood, one of the team's leaders.

For detailed information about HP VEE, please refer to the HP VEE website (http://www.hp.com/go/hpvee) or use the enclosed reply card.

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Printed in the U.S.A 9/97

5966-0368E