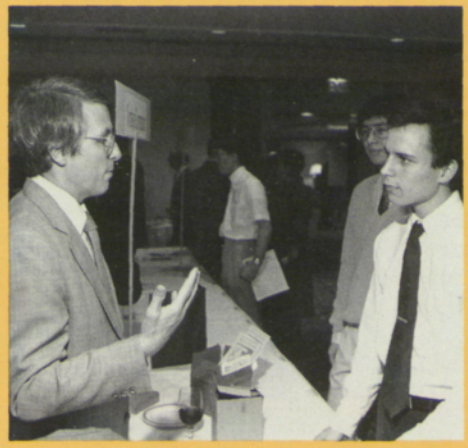
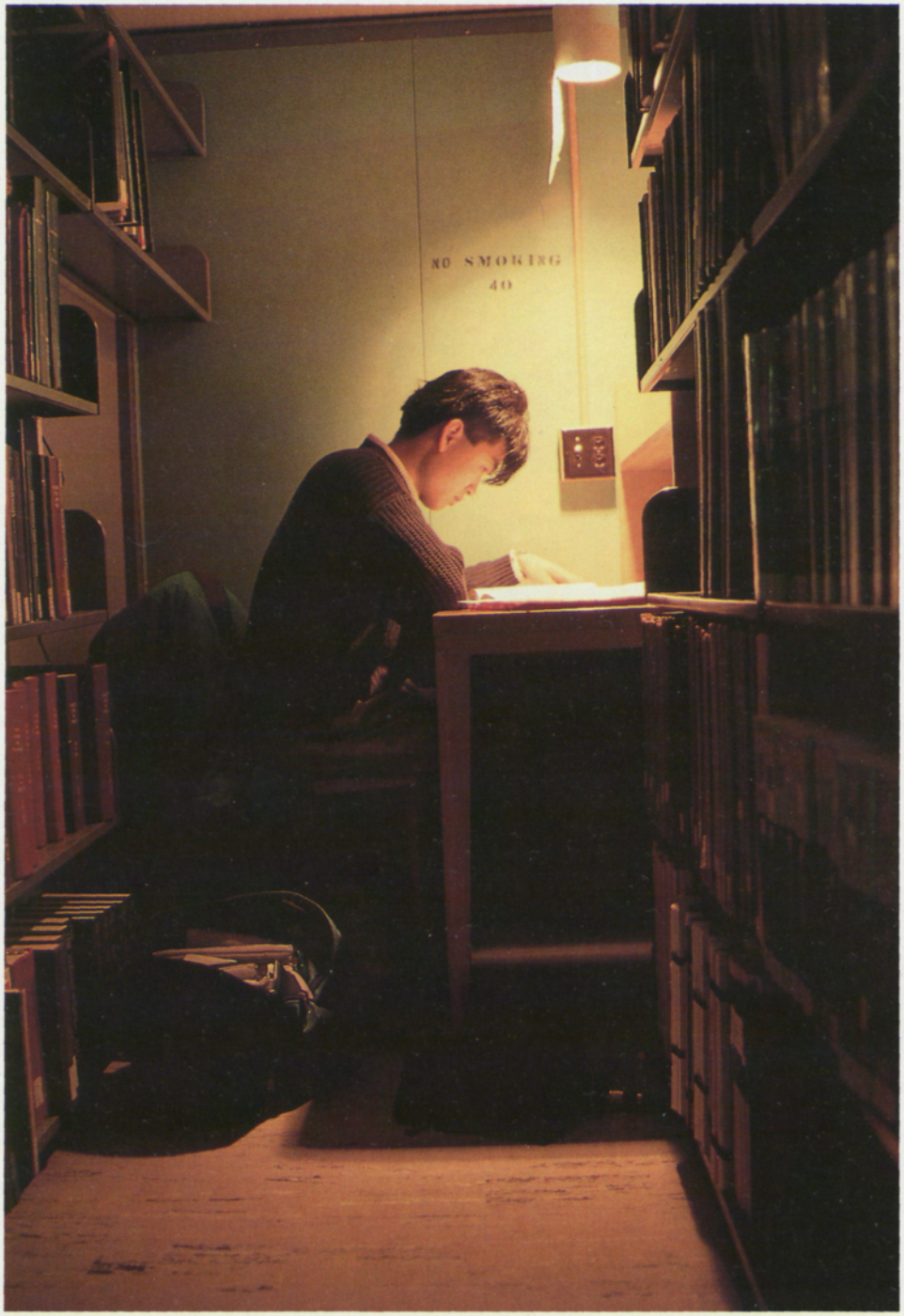
ENGINEERING

CORNELL QUARTERLY



VOLUME 24
NUMBER 3
SPRING 1990

SPECIAL PROGRAMS FOR UNDERGRADUATES



This photograph is by Cornell engineering junior Steven Walton, the first-place winner in a contest cosponsored this spring by the Engineering Ambassadors Association and the Eastman Kodak Company. More than fifty students submitted entries in the photo-essay contest on the theme "Life As a Cornell Engineering Student." Each entry consisted of twelve to fifteen color slides.

The second-place winner was Diana Marsh, a junior; a photo in her series is reproduced on the inside back cover. The third prize went to Mark Schwalm, also a junior. Cited for honorable mention were Frances Nelson, David Rosa, Hal Schnee, and Donald Wong. The prizes, provided by Kodak, were $400 for first place, $200 for second, and $100 for third.

The Ambassadors, a group of student volunteers who work with the engineering admissions office, will use the contest entries in a slide show for presentation to prospective engineering students visiting the campus.

Judges, all from Cornell, were Richard N. White, professor of civil and environmental engineering; Richard Hale, director of engineering admissions; and Chris Hildreth, director of photographic services. The Cornell coordinators were Ambassadors Debbie Skilton, Liza Liew, and Michelle Hom, and admissions staff member Sally Hoekelman Cushing, who is adviser to the Ambassadors. Kodak coordinators were Peter Giles and Bob Bilsky.

Selections from the winning photographs are on display in the Engineering Library.

IN THIS ISSUE

Engineering: Cornell Quarterly (ISSN 0013-7871), Vol. 24, No. 3, Spring 1990. Published four times a year, in autumn, winter, spring, and summer, by the College of Engineering, Cornell University, Campus Road, Ithaca, New York 14853–2201. Second-class postage paid at Ithaca, New York, and additional offices. Subscription rates: $6.00 per year or $9.00 outside the United States.

THE 1990S AS THE DECADE OF THE UNDERGRADUATE

The education of engineers is currently a focus of attention nationally and at Cornell.

The National Science Foundation has predicted that the steadily increasing shortage of engineers will reach 200,000 by the year 2000. The need for improvement in the content and quality of engineering education is also widely recognized, and a number of national groups have conducted extensive studies to determine what should be done. For example, a task force of the American Society for Engineering Education (ASEE) recently identified eight crucial issues for the ensuing decade; they include the need to "repackage" the content of undergraduate programs, improve their quality, implement better laboratory-based instruction, address the role of design, manufacturing, and processing in engineering curricula, improve the quality and quantity of students and their precollege preparation, and integrate computers into engineering curricula as well as into academic research.

These issues are being addressed at the Cornell College of Engineering. Some of the progress is discussed in the articles published here: the college has introduced a program in written and oral communication, expanded the opportunities for undergraduates to participate in research, established an effective program to recruit and retain minority students, and enlarged the work-study opportunities. And there are many additional improvements. For example, the college has an outstanding computer-aided design instructional program (described in a previous issue). Curriculum changes (encouraged by the university through funding for innovative programs) include improvements in basic courses in science and engineering. Courses in ethics, in the history of technology, and in cultural differences in the engineering work environment have been introduced. The effectiveness of new teaching assistants is being improved through mandatory training. Modernizing the teaching laboratories is a major ongoing effort involving the help of government, industry, and individuals. Cooperative programs with industry are on the rise. A novel program featuring weekly meetings of small groups of underclassmen and their faculty advisers provides the students an opportunity to explore aspects of their future profession and individual careers, and a way for the students and professors to become better acquainted.

The ASEE recommendations extend to the related issues of faculty recruitment, the

". . . the steadily increasing shortage of engineers will reach 200,000 by the year 2000."

career-long education of engineers, and the need for increasing the number of professional practice-oriented degree programs. Cornell has been active in these areas also. The highly regarded and increasingly popular M.Eng. program provides a model for advanced practice-oriented education. Furthermore, the opportunity for ongoing professional education at the graduate level is being extended to engineers off campus through a recently established continuing-education program in which class sessions are transmitted via satellite to company locations.

In keeping with the college's current efforts in the area of undergraduate education is its bid to participate in a significant new national program. Eight leading educational institutions, with Cornell as the administrative head, have joined in submitting a proposal under the new Engineering Education Coalitions initiative of the National Science Foundation. A small number of coalitions will be selected to undertake efforts to address the challenges facing engineering education. Support of as much as $15 million over five years will be provided by the NSF, with matching funds to be raised by the coalition.

PURPOSES OF THE NSF ENGINEERING EDUCATION COALITIONS INITIATIVE

- to increase dramatically the quality of U.S. undergraduate engineering education as well as the number of engineering baccalaureate degrees awarded, especially to women and underrepresented minorities.
- to design, implement, evaluate, and disseminate new structures and fresh approaches affecting all aspects of U.S. undergraduate engineering education, including both curriculum content and significant new instructional delivery systems.
- to create significant intellectual exchange and substantive resource linkage among major U.S. engineering baccalaureate-producing institutions and other major and smaller institutions.

In the developments of the 1990s Cornell engineering, as is its custom, is in the vanguard. On the undergraduate scene, the decade is off to a lively start.—The Editor

UNDERGRADS IN THE RESEARCH LABS

Hands-on research was an entirely different way of learning for Steve Bayne, a Cornell junior in mechanical and aerospace engineering who earned academic credit this spring for research on a multicore underwater sediment sampler. "Things aren't already worked out, as in a textbook or a lab experiment," he said. "You design something, build it, watch it fail, redesign it, and finally get it to work."

Bayne was among more than one hundred undergraduates who participated this year in the Undergraduate Research Program at the College of Engineering. The students earn either academic credit or a stipend.

The program, which was available for the third year in 1989–90, is made possible by a gift from James Moore '62 (who manages the research and electrical instrument development at Moore Products Company in Springhouse, Pennsylvania). A total of about $50,000 a year is divided among the projects—seventy this year—to cover stipends, the purchase of equipment and supplies, or computer time.

The popular program greatly expands the opportunities for undergraduates to participate in ongoing research at the col-

Steve Bayne '91 works on a sediment sampler to be used with the robot submarine on the bench. The device, which eventually will be much smaller than the current model, is designed to take core samples of sediments in lakes, rivers, and oceans at depths up to about 600 feet. The cores will include the top "fluff" layer that contains most of the pollutants but is generally blown away by currently available samplers. The device will be mounted, along with other instruments, on a sled attached to the submarine. The submarine has already been tested in the hydraulics laboratory and plans are to test the whole assembly in Cayuga Lake. The faculty adviser for the project is Samuel Landsberger.

lege, according to Christopher Pottle, the associate dean for undergraduate programs. The experience is unusual for undergraduates, Pottle commented. They can share in the difficulties of planning and carrying out "real" research, and in the excitement of discovery and accomplishment.

The students generally find projects to work on by consulting professors or just asking around. Proposals are submitted to the associate dean and funds are allotted. Some of the projects, such as the development of an electrical vehicle, are worked on from year to year, often by teams of as many as forty students. More typically, an individual student works with a single faculty member on an aspect of the professor's current research. Some projects involve the design of a practical object or process, or the development of equipment needed for research; some involve theory, calculations, or mathematical simulation. As a whole, the projects illustrate the wide variety of research activity underway at the college.

Each spring the students present their

(continued on page 10)

Above: Participants in a research program on foundations for power-transmission towers include juniors Tina Montt and Darren Halford and (standing) Charles H. Trautmann, director of the Geotechnical Research Laboratory, where most of the laboratory work takes place. Nineteen graduate students are or have been engaged in thesis research on the project, which is directed by Fred H. Kulhawy, professor of civil and environmental engineering.

The goal of the research is to develop a probability-based design method for the foundations; better design methods could result in savings to United States consumers of over $1 billion during the next several decades. The eleven-year, $4.5-million project is funded by the Electric Power Research Institute.

The laboratory computer facility where the photo was taken is used to control tests of model foundations in soil deposits. These tests simulate real foundation systems and permit parametric studies that would be too expensive to conduct in the field.

In the photo at right the researchers are working in a laboratory chamber used to test model soil/foundation systems. Here steel forms have been prepared for construction of model foundation columns. After soil is placed around the forms, they are filled with concrete and withdrawn. Then, after the concrete has cured, the foundations are tested in a variety of loading configurations.

Team work on vehicles is popular among the student researchers, as the projects described on these pages demonstrate.

Right: This year's project for forty students working on a battery-operated electrical vehicle was to design, build, and test a 20-inch model; next year the plan is to build a full-scale car. The model with all systems installed had just successfully passed its first performance test when this photograph was taken. Left to right are Jon Russo, Dan Roitman, Andrew Chiang, and Chris Bett.

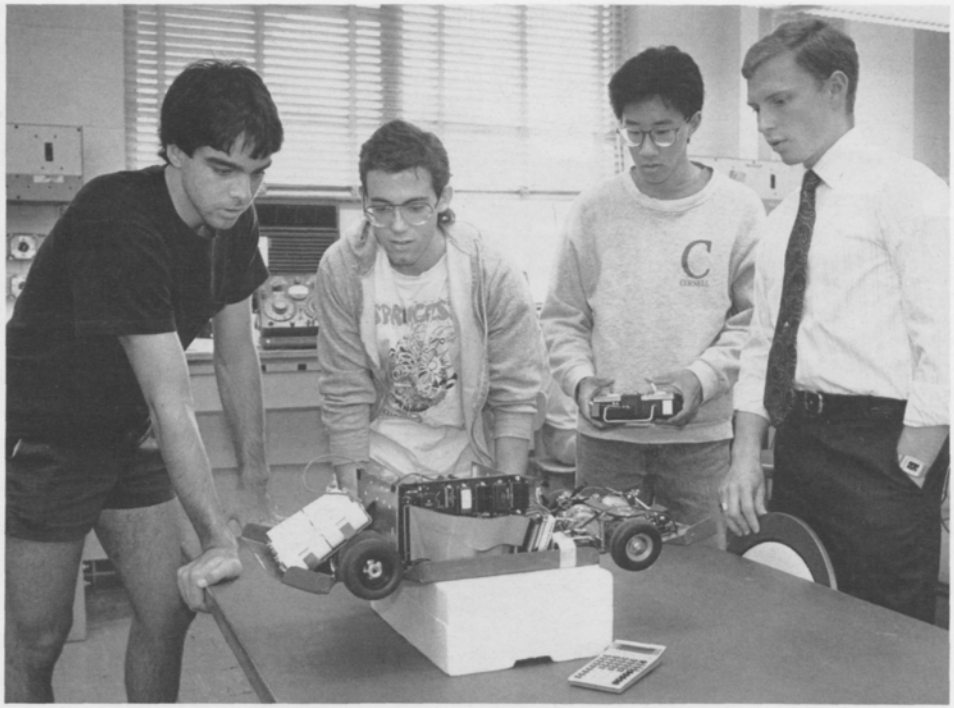
Group leaders were Russo, Regenerative Braking Systems; Roitman, Active Noise Abatement; Bett, Motor Control and Drive Systems; Steve Chiou, Display Instrumentation; Kevin Stark, Test Instrumentation; Daniel Berrien, Mechanical Systems; and Kim Griffith, Power Sources. John Belina and Robert Thomas were the faculty advisers.

Right below: This spring a radio-controlled cargo aircraft designed and built by six students was entered in a national competition in Long Beach, California. The Cornell plane placed twelfth out of some fifty entries. The photograph was taken at the site by student team leader Nicholas Tiliakos.

In the competition, which is sponsored annually by the American Society of Automotive Engineers, each plane has the same kind of engine, cargo-bay dimensions, and total planform area; points are awarded on the basis of the weight of payload lifted (the Cornell plane carried 13.25 pounds), quality of plans, oral presentation, and performance analysis.

Team members Tiliakos, Matt Kennedy, Darin Spilman, and John Mayer made the trip, accompanied by faculty adviser C. Thomas Avedisian (a radio-controlled-aircraft buff). Jim Glynn and William Denise were also on the team, and Mark Psiaki was a faculty adviser.

Project work included design and analysis, wind-tunnel testing of parts, and computer simulation of performance. Since the design of full-sized aircraft entail the same processes, the students gained practical experience.



Left: A human-powered vehicle will be entered in a national competition in Portland, Oregon, in August. When this photo was taken, just after spring break, only the frame of the second prototype had been assembled. Shown with it outside Thurston Hall, where the team's lab is located, are (left to right) Loy Kuo, John Huang, John Garrity, Paul Perkowski, Antonio Williams, Louis Algaze (seated on the vehicle), Todd Pines, Francis Vanek, Andy Hazelton (the group leader), and Jon Glick. The faculty adviser is Samuel Landsberger.

The sixteen students working on the project were divided into three teams, for the frame, the power train, and the fairing. General Electric supplied plastic for the bubble-shaped fairing.

According to Garrity, who is in charge of public relations, the design objectives are practicality and safety rather than speed. Safety features include road stability, good visibility for the driver, a roll bar, and a seat belt. The three-wheeler is easy to pedal and capable of carrying a load. Eventual marketing of the vehicle is a possibility, Garrity said.

Left below: Cornell's 1989 Formula SAE race car was out for a test drive on campus when this photo was taken.

In the spring of each year the current model of the Cornell car is entered in a national competition. In the past three years, Cornell's entry has won some of the top honors for design and performance.

This year's team consisted of eighteen undergraduates and two Master of Engineering students. The project is conducted as part of a course that combines classroom instruction with the hands-on experience. A. R. George, professor of mechanical and aerospace engineering, teaches the course.

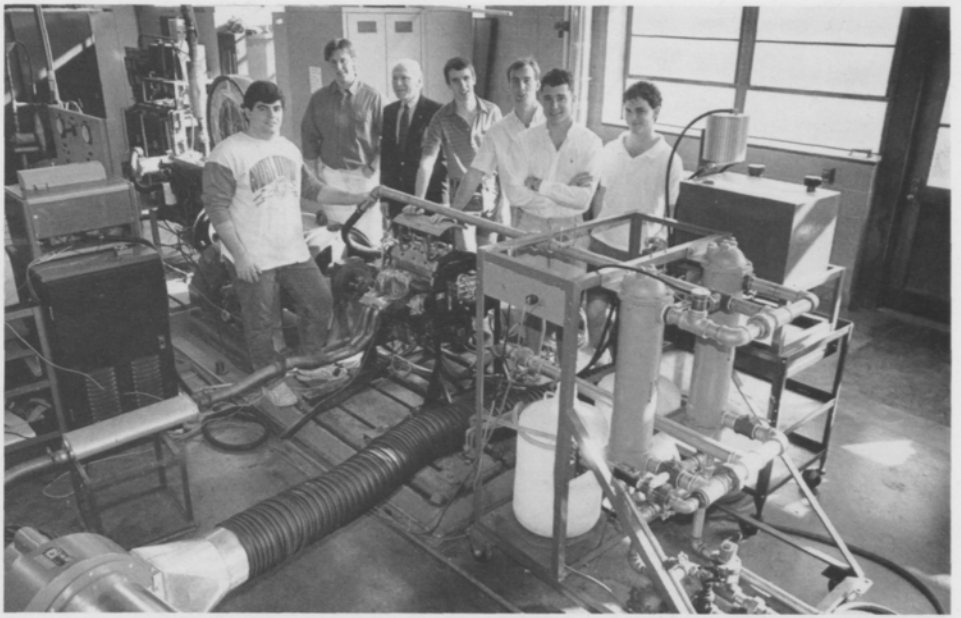
In the fall term the students worked on chassis tuning and frame design. In the spring Robert Roller headed a team that worked on heat-transfer aspects, and Frank Robinson and his team worked on manifold tuning. The electronic ignition system was designed by Josh Kablotsky, an electrical engineering student *(see page 10).*

". . . the projects illustrate the wide variety of research activity underway at the college."

PRESENTATIONS AT THE 1990 UNDERGRADUATE RESEARCH FORUM

Topic	*Student Speakers*	*Advisers*
Scheduling Projects with Shared Resources	Ray Datta	Lee W. Schruben
Thermodynamic Modeling of Liquid Mixtures of Chemical Compounds	Edward Hall	John A. Zollweg
Changes in Soil Stress	Tina Montt	Charles H. Trautmann
Submersible Deployed Multi-Core Sediment Sampler	Stephen Bayne	Samuel Landsberger
A Microwave Antenna Range for Operation Over the Range 5 GHz to 100 GHz	Jodi Schwartz	Richard Compton
1/f Noise in Copper Nanobridges	Timothy Shaw	Robert A. Buhrman
Behavior of Drilled Shafts Subject to Lateral and Moment Loading	Darren Halford	Charles H. Trautmann
Spark Advance Control System	Joshua Kablotsky	John Belina
Sensitivity Variation of Contact Transducers Over Their Aperture	Robert Kubarek	Wolfgang Sachse
Computer Projects for Math 293–294	William Kallock	Richard Lance
Aeroacoustic Study of Motorcycle Helmets	Eric Walsh	A. R. George
R/C SAE Cargo Aircraft Competition Project	Nicholas Tiliakos Matthew Kennedy Darin Spilman	Mark Psiaki C. T. Avedisian
Instantaneous RPM Measurement in the Quad-4 Engine	Sean C. Forbes	W. W. Gunkel
Analysis of GaAs/AlAs Superlattices Using Scanning Transmission Electron Microscopy	Stuart Friedman	John Silcox
Optical Transducers to Measure Hypersensitivity Skin Tests	Scott McCormack Louis Nisivoccia	John Belina
"Active Ground Effects" to Improve Race Car Performance	Saif-Deen Atwell Eric Davis	A. R. George
Wind Tunnel Testing	Herbert Derrow	A. R. George
Wind Tunnel Modification and Calibration for High-Speed Testing	Robert Beaubien	A. R. George
Ion Beam Analysis of Paint Pigments	Barbara Cho	James W. Mayer
Design of a Human-Powered Commuter Vehicle	John Garrity Andy Hazelton	Samuel Landsberger

Above: Bill McGurk, a M.S. candidate in agricultural and biological engineering, coordinated teams of undergraduates working on the development of instruments for testing the fuel efficiency of engines. McGurk began the project two years ago.



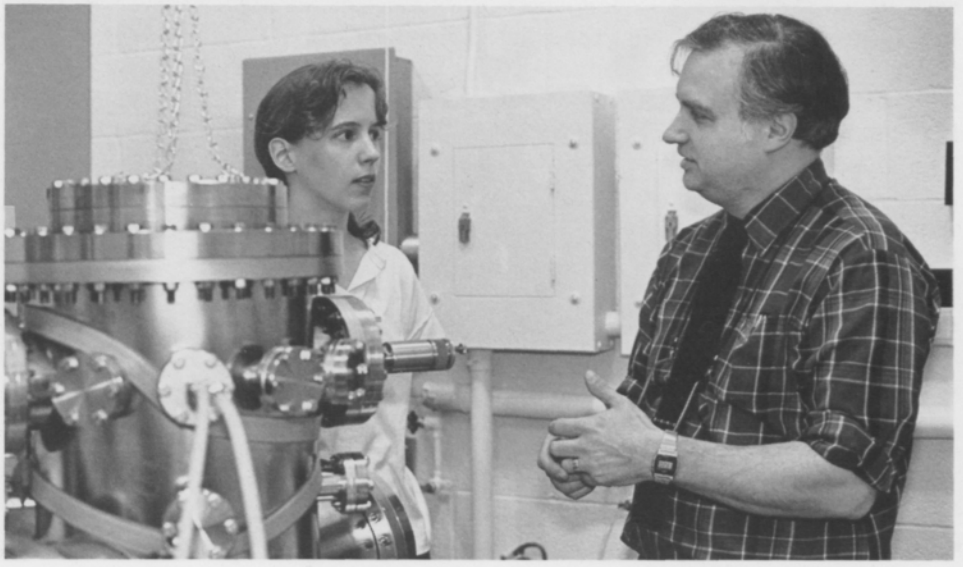
The collaborators on this year's teams gathered for a photograph with McGurk and their faculty adviser, Wesley Gunkel. Left to right are Husam Yousif, Matt Atwood, Gunkel, McGurk, Stephen Grant, Sean Forbes, and Phil Wasserman. In the spring term Forbes worked on an optical method of measuring the speed of a Quad-4 engine, and Yousif and Atwood worked on dynamometers.

The same instrumentation developed for the Quad-4 engine can be used to measure the performance of the diesels that usually power farm machinery.

Right: Senior Lisa Anderson worked with Michael Isaacson, professor of applied and engineering physics, on subwavelength apertures for a novel optical microscope. Development of the high-resolution microscope is a major research project for Isaacson and his group.

Because the instrument will not use lenses and will not be limited by wavelength, it will be capable of producing optical images comparable in resolution to electron micrographs, but with less damage to samples.

Anderson explained that she began her part of the project by calculating the feasibility of an improved method for forming the crucial apertures. Aluminum deposited by vapor deposition will be ionized before coating the tip of a tiny glass pipette.



Left: In an undergraduate research project in electrical engineering, Scott McCormack takes a turn as patient while his research partner, Louis Nisivoccia, conducts skin tests to monitor the status of the human immune system. Their faculty adviser is John Belina (standing).

The project goal is to improve the accuracy of a conventional method of testing for cell-mediated immune-system competency using a commercially available kit. The improved measurement scheme depends on visual assessment of variations in skin reflectivity following the introduction of an allergen at the test site.

The student researchers monitored the epidermal response using reflected infrared light detected by photo-transistors. Computer-controlled hardware allowed rapid sampling among eight test sites. Optimal placement of the infrared emitter and detector were determined, and sensors were introduced into the apparatus to correct for variations in skin temperature and ambient room temperature.

Left: In another electrical engineering project, Josh Kablotsky developed an electronic ignition system with variable spark advance for the Formula SAE race car (page 7). The custom electronics are expected to provide the engine with increased power output and fuel efficiency. John Belina was the adviser.

research results at the Undergraduate Research Forum, a stimulating event attended by other students, faculty members, and engineers from industry. Also, many of the student researchers participate in a poster session at the annual Engineering Conference, which is sponsored by the college and the Cornell Society of Engineers and attended mainly by alumni.

This year two papers by students in the Undergraduate Research Program were selected for presentation at the fourth annual National Conference on Undergraduate Research, which was held in April at

The Undergraduate Research Forum on April 29 started at 11:45 and wound up six hours later with a reception. A center of attention at the reception was the human-powered vehicle (page 7). James Moore '62, the Undergraduate Research Program sponsor, is at center in the photo.

Union College. Darren Halford's paper was on his research on foundations for power-transmission towers (see page 5); Scott McCormack and Louis Nisivoccia presented a paper on electrical transducers to measure the human immune systems. More than a thousand students and faculty members attended the multi-disciplinary conference, whose sponsors include the Council of Undergraduate Research, the National Science Foundation, honorary societies, and corporations.

In addition to the projects supported by the Moore fund, there are a number of other research opportunities available to undergraduates. Students can be paid assistants in projects sponsored by the National Science Foundation, other government agencies, and industrial organizations. Also, engineering students are eligible for participation in the recently established Cornell University Research Apprenticeships program.

A growing number of summer programs for undergraduate researchers adds to the number of opportunities. Last summer, for example, Cornell engineering students participated in National Science Foundation Research Experience for Undergraduates programs at the School of Civil and Environmental Engineering and at the Cornell National Supercomputing Facility. These programs also involve follow-up research during the academic year.

The faculty as well as the students are enthusiastic about undergraduate participation in research, according to Professor Richard N. White, who was instrumental in developing the opportunities during his recently completed term as the associate dean for undergraduate programs. The students, he said, have proved to be "exceptionally capable, with the talent, curiosity, and enthusiasm so important in any research endeavor." Moreover, he said, the Undergraduate Research Program "has provided a new and vital strengthening of the link between teaching and research. We believe that in the university of the future, research and teaching and learning will tend to merge into one continuous effort."

Many of the undergraduate researchers are still undecided about the directions they hope their careers will take, but they all seem to agree that their research participation has given them a wider view of science and engineering, and experience to augment their education in classroom and student lab.—GMcC

CORNELL'S ENGINEERING MINORITY PROGRAMS:

Developing a Needed Resource

Begin early and provide a rich assortment of special opportunities. These are the keys to success in minority-education programs, the Cornell College of Engineering has found.

Increasing the enrollment—and retention—of students from underrepresented minorities is a major aim of the college, and also a big challenge. Many talented minority students have a less than optimal preparation for entering a demanding program like Cornell's, and once on campus, they often need special kinds of support.

Some years ago, administrators at the college decided to meet the situation aggressively with fresh ideas. The result is a cluster of Engineering Minority Programs that are now serving as models for institutions around the country. They involve more than two hundred students on campus, plus hundreds of potential engineers as young as ninth graders.

The broad purpose, Dean William B. Streett explained in a recent report to the faculty, is to "increase the numbers and retention rates of minorities, not just because these groups deserve equal opportunity, but because their low representation in the work force of scientists and engineers is rapidly becoming a major national problem."

He pointed out that by the year 2000, more than 40 percent of the college-age population in the United States will be African American and Hispanic. These groups now make up about 22 percent of the college-age population, but only 10 percent of engineering undergraduate enrollments nationwide. The alarming fact is that the number of minority matriculants in engineering is low and dropping.

At Cornell the Engineering Minority Programs serve students from underrepresented minority groups (African American, Hispanic, and Native American), and also some Asian and disadvantaged nonminority students. At the college, underrepresented minority groups make up about 10 percent of the total undergraduate enrollment of about 2,600.

The programs are directed by Assistant Dean Mary Thompson.

ENGINEERING FOUNDATIONS: TAKING TIME TO DO IT RIGHT

An innovative program that is receiving much attention nationally is the Engineering Foundations Program, which allows selected minority students to take five years instread of four to earn a B.S. degree, and provides an extensive support system.

Students who would be likely to benefit from the program are identified in the course of the regular college admission process, and are offered admission specifically to the Foundations Program. In general, they are students who have done well in high school, but whose schools have not provided adequate curricula and preparation for study at a major university.

The great strength of the program, Thompson said, is its "holistic approach, which addresses not only academic problems, but the extra stress often experienced by minority students at a predominately white university."

Why the extra undergraduate year? Many Cornell engineering students take more then eight semesters to complete the B.S. degree requirements, but records show that minority students are particularly likely to require additional time. Some have taken five years to finish, and a few have taken six. Sometimes this happens because a student needs to repeat one or more courses that are offered only in a sequence. Sometimes, because of poor

". . . by the year 2000, more than 40 percent of the college-age population in the United States will be African American and Hispanic."

academic performance, a student is suspended for one or more semesters, or is advised to take a reduced course load.

One of the unfortunate consequences is that these students often find themselves enrolled in classes throughout the calendar year, precluding the possibility of gaining practical experience in summer employment. Another effect is that such a student's transcript does not look promising to prospective employers or graduate schools. These circumstances are discouraging, to say the least; many minority students abandon engineering rather than experience them.

One way the Engineering Foundations Program counteracts these problems is by allowing three years instead of the normal two for the first half of the engineering curriculum (see the table). The Common Curriculum, as this part of the undergraduate program is called, consists of basic courses designed to develop skills in math, science, computing, and writing, as preparation for upperclass work in a chosen engineering field. The modifications introduced by the Foundations Program do not reduce or change degree requirements. What the program does is allow room in a student's schedule for supplementary academic work and for special services and opportunities.

Particular attention is given to course work in the essential areas of mathematics, physics, and computing:

- To help ensure a solid basis in mathematics that will enable the students to handle the regular math sequence, a special year-long Engineering Science course has been developed by faculty members in engineering and mathematics. The concepts of precalculus, calculus, computer science, and physics are emphasized.

THE ENGINEERING FOUNDATIONS PROGRAM

Courses that differ from those in the normal two-year curriculum are shown in boldface. The amount of academic credit is in parentheses. All courses carry credit that appears on the student's transcript, but only those in the normal curriculum give credit toward the degree.

	Fall	***Spring***
Year 1	Freshman Seminar (3)	Freshman Seminar (3)
	Introduction to Engineering (3)	Humanities course (3)
	Computer Science 101 (4)	Computer Science 100 (4)
	Engineering Science 141 (3)	**Engineering Science 142 (3)**
	Enrichment Seminar (1)	**Enrichment Seminar (1)**
Year 2	Mathematics 191 (4)	Mathematics 192 (4)
	Humanities/Social Sciences elective (3)	Engineering distribution course (3)
	Chemistry 211 (4)	Humanities/Social Sciences elective (3)
	First half of Physics 112 (2)	Second half of Physics 112 (2)
	Enrichment Maintenance (1)	**Enrichment Maintenance (1)**
Year 3	Mathematics 293 (4)	Mathematics 294 (4)
	Physics 213 (4)	Physics 214 (4)
	Engineering distribution course (3)	Engineering distribution course (3)
	Elective (3)	Elective (3)
	Elective (3)	

Freshmen in the Foundations program attend a weekly Enrichment Seminar throughout the year. It is a time for companionship as well as orientation and learning. Dean Mary Thompson, who appears in two of these photographs, coordinates the seminar series.

Classroom instruction is augmented with workshops, and specially chosen teaching assistants provide tutoring when needed.

- For Foundations students, the normal one-term introductory course in physics (112), which covers mechanics, heat, and light, has been spread out over two terms during the second year.
- Before taking the regular beginning course in computer science (100), Foundations students take 101, a slower-paced course in computing fundamentals.
- Each term of the freshman year, every student in the college takes a seminar that emphasizes writing. These seminars are offered in a variety of subjects by Cornell faculty members in the College of Arts and Sciences; Foundations students receive guidance in choosing the seminars that will be most helpful.
- Foundations students take special "enrichment" seminars throughout the first two years. Weekly meetings cover such aspects as study skills and time management, and talks and trips help develop an awareness of real-world engineering. Attention is given also to matters of cultural identity and self-confidence. These intangible qualities, Thompson emphasized, have an immeasurable but strong influence on students' academic achievement, and later on their professional success and effectiveness.

The program also draws on the wide range of services and opportunities that are offered to all minority students through the Engineering Minority Programs Office. These include extensive counseling and tutoring, and opportunities for industrial internships and visits to company sites.

According to Professor Richard H. Lance, who has been particularly active in the development of special programs for undergraduates, the effectiveness of the Foundations Program curriculum is under evaluation, and revisions may be made on the basis of how well the students perform. By the end of the first year, two from the group of nineteen (which included three regularly admitted freshmen who asked to join the program) were "mainstreamed" in calculus, two had dropped out of the program, and four had transferred to other Cornell colleges. Most had acceptable grades, some as high as a B+ average. Last fall there were twenty-five first-year students in the program.

A VARIETY OF ACADEMIC SUPPORT SERVICES AND PROGRAMS

Special programs for minority students begin well before the freshman year.

A program for high school students is Minority Introduction to Engineering (MITE), which brings them to campus for a week during the summer between their junior and senior years. The idea is to acquaint them with the various engineering disciplines and the special options available at Cornell. The visitors attend classes and talks by faculty members, administrators, and representatives from industry. And, perhaps most importantly, they meet Cornell engineering students.

Once they have been offered admission to the College of Engineering, students from underrepresented minority groups are invited for a three-day campus visit. This is an important event, for a campus visit is often a deciding factor in the choice of a college. The prospective Cornellians live with and meet students, attend engineering classes and demonstrations, and participate in discussions about financial aid, minority affairs, Cornell's Learning Skills Center, and dormitory life.

The summer before the freshman year, the university conducts a session designed to give early guidance, build confidence, and increase the likelihood of academic success. About one hundred fifty students, including about twenty-five in engineering, participate each summer.

Throughout the underclass years, the students can take advantage of one-on-one and small-group tutoring that is offered in the subject matter of most of the engineering courses. In addition, peer counseling of a more general nature is offered by upperclassmen in formal and informal group meetings. The counselors share experiences and insights, helping the younger students assume control of their educational progress. To supplement and enlarge the scope of available counseling, a program in which alumni and interested professionals in industry act as mentors to students is being developed.

And then, of course, there is the Engineering Minority Programs Office, with a staff always ready to provide counseling. The office is generally full of students, who seem to regard it as a focal spot on campus.

HELPING MINORITY STUDENTS DEVELOP CAREERS

Close associations with industry enrich the college experience and help the students prepare for professional work.

One way in which corporate representatives and minority students come together is through a program of seminars in which company people lead discussions on subjects ranging from technical specialties to job interviews and issues of sexism and racism in the corporate culture.

An annual event is the Engineering Minority Career Fair, at which industrial representatives provide information about their organizations. The fair gives the students and the corporate representatives opportunities to discuss job and career possibilities. A highlight is a banquet at which the participating corporations present awards to African American, Hispanic, and Native American students who have made especially good academic progress.

A program that has been in place for many years and is still going strong is Project VIEW, which enables minority engineering freshmen, sophomores, and juniors to visit corporate sites for three to five days during winter intersession. The students get a first-hand view of engineering work and meet practitioners, and the experience helps them choose a specialty field and course of study. Sometimes opportunities for Engineering Cooperative Program assignments or industrial internships develop from contacts established through Project VIEW.

The Engineering Minority Programs Office is hoping to arrange corporate internships for students at all class levels. Hands-on experience, even if it is brief, is effective both in acquainting students with the realities of industrial employment and stimulating academic achievement. Sometimes the association develops into permanent employment after graduation.

Corporate involvement is a valuable asset in all the Engineering Minority Programs, Thompson pointed out. This takes the form of financial support through scholarships, awards, and program funding, and also direct participation in the programs themselves. Recently, for example, IBM arranged to have a staff member with experience in engineering, education, and program development spend two years on campus working directly with the college staff. Such cooperation not only benefits the students, but also enhances affirmative-action programs in industry, Thompson remarked.

A significant program for students with the ability and desire to undertake graduate study is offered by GEM—the National Consortium for Graduate Degrees for Minorities in Engineering. The consortium, made up of some fifty universities, including Cornell, and fifty companies, awards fellowships covering tuition, fees, and a stipend for study at any university that is a consortium member and has offered admission to the particular candidate. A summer internship at one of the sponsoring companies precedes the beginning of graduate study. Currently, six GEM

(continued on page 18)

Engineering at Cornell for Two Students in the Foundations Program

The Cornell experience for a student in the innovative Engineering Foundations Program has an extra dimension. Besides the classes and extracurricular activities, the dorm life and new friends, and the enjoyment of campus and town, there is the support of the program and everyone associated with it. Scenes from the Cornell life of two Foundations students—Marlene Mulero and John Belizaire—are shown on these pages. Like the forty or so other Foundations students, they began the program while still in high school and plan to graduate after a five-year course of study.

1. Marlene, a second-year student from New York City, lives in Balch Hall this year. She keeps a pair of rabbits (normally caged) in her dorm room.

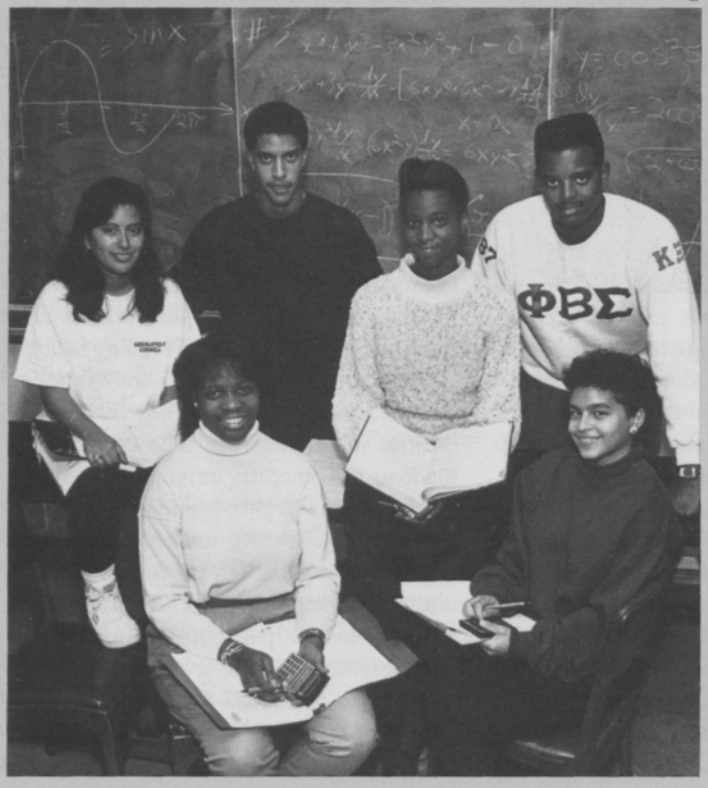
2. Foundations seminars meet weekly; these students are part of the second-year group.

3. Marlene's faculty adviser is Richard N. White. She has a busy extracurricular as well as academic schedule—she is active in the Society of Hispanic Professional Engineers, and she meets often with a group of freshmen for an activity such as ice skating at Lynah Rink.

4. Marlene's math tutor is senior Mark Johnson.

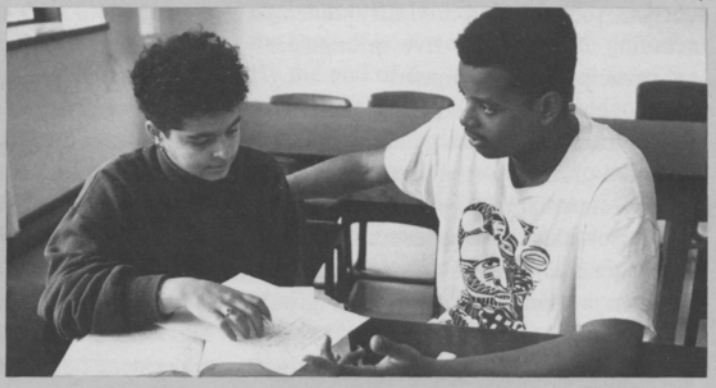
1

2



3

4



5

5. Marlene's favorite lab class is the one for Mechanical Properties of Materials, with Polly Chu as the teaching assistant. Marlene plans to major in mechanical engineering.

6. Both John and Marlene enjoy having their bikes with them at Cornell. Here they are by the sundial, a focal point on the engineering quad.

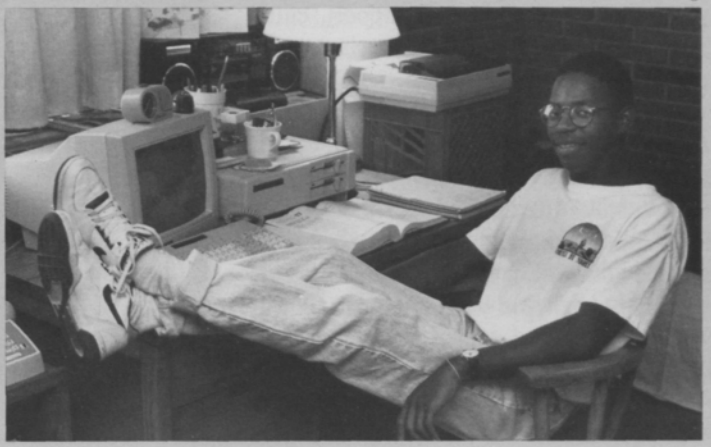
7. The shore of Beebe Lake near his dormitory, High Rise 1, is a good place for John to practice Tae Kwon Do.

8. John, a freshman from New York City, hopes to work for a large computer company, or maybe start his own computer-services business. He makes extensive use of his computer in his dorm room. He likes the Foundations program mainly because it gives a student time to "build a base" for college work. The program's support system and network with companies are very good, he says. He visited Intel Corporation with Project VIEW, and this summer he will have a job there.

6

7

8



Cornell Young Scholars come to campus each summer for two weeks of study, discussion, and team project work. Last summer this group carried out a biology project.

scholars are enrolled at Cornell; the program here is administered by the Engineering Minority Programs Office.

EARLY CONTACT THROUGH THE YOUNG SCHOLARS PROGRAM

A key to the success of all the efforts and programs at the college level is the nurture of prospective students long before they get to the point of applying to college. Experience shows that to be fully effective in recruiting and retaining qualified minority engineering students, the college must begin its efforts early in the students' lives, take the initiative, provide financial, academic, and psychological support, cultivate self-confidence and enthusiasm, and open up avenues of opportunity. This is, in fact, the ambitious agenda that has been worked out by the Cornell Engineering Minority Programs Office.

Students might first become aware of Cornell's engineering college when they are in junior and senior high school—a crucial period, when courses are being chosen and attitudes and expectations are being developed. The contact is made through the Cornell Young Scholars Program, an innovative outreach and enrichment pro-

gram for underrepresented minority students that was pioneered in the College of Engineering (as MYSEAT—Minority Youth and Students Exploring Avenues in Technology) and has expanded to include students interested in other Cornell colleges and fields of study.

Initially, the approach is to encourage appropriate pre-college studies and participation in science projects and competitions. Enrollment begins in the ninth grade, upon recommendation of teachers and counselors, and continues through the summer after high school graduation. Motivation includes a lay-away scholarship plan for students who eventually come to Cornell: cash awards are made for high grades in math, science, and English.

The students attend a two-week session on campus each summer for three years, taking courses in English, mathematics, and science, and participating in cultural-awareness and enrichment activities. They also receive counseling in such areas as choosing a college and a career. Faculty members and professional people describe the kinds of work done in the fields of mathematics, chemistry, physics, engineering, psychology, and health care, and how high school students can begin preparing for science-related careers. Other features of the summer program are tours of laboratories and special facilities at Cornell and site visits to nearby industries. The students are especially enthusiastic about participation in a team science project carried out during the session.

During this period, the students are also evaluated for engineering aptitude, including their abilities and aptitudes in reading, writing, problem-solving, and the use of representations such as equations and graphs. Noncognitive factors that aren't assessed in predictive tests such as SATs are also evaluated by means of a specially developed questionnaire. Qualities that are looked for include self-confidence, realistic self-appraisal, an understanding of racism and how to deal with it, and the ability and willingness to work toward long-term goals. Other factors that have been found to contribute to academic and career success, and are looked for among the Young Scholars, are the availability of a strong support person, leadership experience, and a record of community service.

As a followup to the summer session, the students return to Cornell one Saturday a month during the academic year. In the spring the program sponsors a fair at which the students present projects they have worked on during the year.

Parents are involved through discussion meetings on ways in which they can encourage their children to pursue higher education, and on practical matters such as application procedures and financial aid.

The program is partially funded by the Pew Foundation with matching grants from corporations. It relies on industrial support not only financially, but through direct participation: company representatives serve as speakers for on-campus sessions, as hosts at site visits, and as mentors to individual students. These corporate partners in the Young Scholars Program include Corning Incorporated, Eastman Kodak, General Electric, IBM, and Xerox.

The first group of Young Scholars—twenty-two students from selected schools in the upstate New York communities of Ithaca, Syracuse, Binghamton, Rochester, and Elmira—were selected and enrolled in the summer of 1988. Last summer, with the addition of a new group of ninth graders, and the expansion to a university program, the enrollment grew to forty-five. Also, the program was extended to involve ten teachers from the same high schools, who taught the courses in conjunction with Cornell faculty consultants and graduate teaching assistants. These teachers, the parents of the students, and industry mentors were invited to join the group on a Saturday. This summer a full complement of about sixty students is anticipated.

Although this program involves a relatively small group of students, Dean Streett remarked, it is significant as a model. Its effectiveness, he noted, owes much to the partnership of the university, the public schools, private industry, and a private foundation. "This effort to develop a pipeline of competitive minority-group scholars for tomorrow's colleges and professional positions is one of the most important activities the college is now engaged in," he said.

This assessment extends to all the Engineering Minority Programs at Cornell. As Streett put it, their "depth, strategy, and long-range view represent a viable attempt to help solve one of the nation's most critical problems: the impending shortage of scientists and engineers accompanied by an underdevelopment of talent among minority groups."—GMcC

SKILL WITH WORDS:

A New Emphasis in the Education of Cornell Engineers

by Penny Beebe

In today's complex technological world, engineers must have not only technical competence, but skill in writing and speaking. At Cornell the engineering college is in the third year of a program that is working to strengthen our undergraduates' writing and oral-presentation skills.

The Engineering Communications Program began in 1987 with an effort to help a few interested engineering faculty members build writing into their courses. Under the leadership of Steven Youra, the director, the program has steadily expanded in both size and scope: three additional experienced teachers of writing—Susan Hubbard, David Adams, and I—are now on the faculty, and besides continuing our work with engineering courses, we offer a course of our own, Engineering Communications (Engineering 350).

THE COLLEGE'S FIRST COURSE IN ENGINEERING COMMUNICATIONS

The students in Engineering 350 bring to class a wealth of technical information, and whether or not they happen to be adept with language, they are bright, generally talkative, and quick to draw on their training. Assignments—devised by each instructor for his or her sections—are designed to take advantage of what the students know as proto-engineers as well as to give them experience as writers and speakers.

For instance, Adams asks his students to identify and analyze a procedural, organizational, or mechanical problem and to write a recommendation report proposing a solution. The organization and content of the report depend largely on whether the intended readers are staff engineers, managers, or upper-level administrators. The term project in his classes is a long document such as an instruction manual, a report of original research, or an expansion of the earlier recommendation report, and it culminates in an oral presentation.

Hubbard asks her students to review an actual—and chaotic—progress report written by an engineer at a radar installation and to submit written guidelines for revising the wayward document. She also asks them to analyze the graphic and textual elements of a brochure used by an engineering consulting firm; the resulting suggestions for improvement are sent to the firm, whose engineers return the favor by commenting on the students' ideas.

Youra's summer-session class is offered primarily for students who will be working at co-op jobs during the fall term. For one of his assignments, teams of students design and build a mechanism (the only requirement is that it have at least one moving part), using a kit of components—Tinkertoys and rubber bands. Among objects that have achieved brief fame are a high-tech weather vane, a toy car, and a gourmet food chopper. Once the designs are complete, each team writes assembly instructions that are then tested by another team. Finally, each team revises its instructions, prepares a user's manual (with graphics), and gives a marketing presentation of its product.

One of the assignments in my classes requires each student to define a technical concept in three ways: for professionals in the field to which it applies, for engineers with different specializations, and for non-engineers who must comprehend the concept's fundamental principles. Another assignment presents an actual case in which engineers at three levels in a company have violated, to different degrees, the code of ethics of the Accreditation Board for Engineering and Technology (ABET); the students analyze the situation

Left: Checking out their instructions for assembling their Magic Kitchen Utensil from Tinkertoys are Louis Lanzerotti, a junior engineering physics major (at left), and Basil Demeroutis, a junior in mechanical engineering. They and their teammate Tom Easley, a junior in materials science and engineering, designed the machine and wrote assembly directions for another team to try out. The point of the exercise, assigned in Steven Youra's writing course, is to sharpen skills in writing technical material clearly and presenting it effectively in printed form.

as if they were regional officers of the professional societies in their respective fields of study.

In the sections taught by Hubbard, Youra, and me, the term project is a feasibility study for which each student chooses a technical topic, researches pertinent literature, writes a feasibility report, and orally presents major findings; related assignments include writing a proposal and one or more inquiry letters, interviewing professionals, and preparing a progress report. Often these activities are more than exercises; the letters are written to real people, and every report is read by someone in an engineering department or in industry.

ASSESSING THE COURSE AND HOW IT COULD BE DEVELOPED

From the instructors' point of view, Engineering 350 is successful because it combines rigorous standards, interesting

SOME STUDENT PROJECTS IN ENGINEERING COMMUNICATIONS

Manuals:

A LAN Installation Manual (for technicians working with Network Resources at Cornell)
A PC-Based Voice Recognition System (a documentation of public-domain software)
NCR Printer Assembly Manual (for line workers at NCR's Ithaca plant)
Determining Drag on a Cylinder: The M&AE 427 Wind Tunnel Experiment (a revised manual)

Feasibility Studies:

Bridging Cayuga Lake
Reorganizing and Upgrading Computer Facilities Available to Engineering Students
Finding an Economical and Practical Database Manager for the Dickson Hall Mail Room
Using Fly Ash as a Soil Supplement
The Applicability of Liposomes in Fighting AIDS
Environmentally Friendly Alternatives to Disposable Diapers
The Feasibility of Using an Optical Scanner to Detect Missing Items at Olin Library
The Feasibility of Installing a Baggage Claim Carousel at Tompkins County Airport
Substituting Aluminum for Steel in American Automobile Frames
Computerizing an Antiques Business
Understanding and Selecting a Stereo Component System
Restoring a Classic British Sports Car—Factors to Consider

". . . by the end of the semester, the students see themselves as seasoned writers, weary yet wise."

subject matter, and the continual interaction of everyone in the classroom. Students learn to write in a range of formats, for different purposes, and for different audiences. They discuss each other's papers and presentations. They grow increasingly comfortable speaking to a group. And they think of themselves as engineers and communicators, working hard (as they frequently point out) to blend the seemingly unrelated intricacies of two domains.

The students have different attitudes about Engineering 350 depending partly on where they are in the semester. The workload is sizeable: the students write from eleven to fourteen assignments, roughly a paper a week; they analyze the design of visuals and produce their own, often on a computer; and they give two or three oral presentations. Moreover, the emphasis is on the most difficult component of the course—writing. I have found that initial enthusiasm (or tentativeness, as the case may be) gives way after a few weeks to a sober recognition that words are slippery things governable less by "rules" than by the writer's determined scrutiny. Near the middle of the semester, it is inescapably clear that good, efficient writing is the result of *time spent working for it* and that efficiency is a complicated goal. But by the end of the term, the students see themselves as seasoned writers, weary yet wise. They have labored all semester to think clearly and to use words accurately, and now they have produced a complicated text, created appropriate graphics for it, and assembled these materials for an oral presentation. Engineering students do love technical information, and just as the feasibility reports challenge their ability as writers, the presentations give them a chance to publicly demonstrate what they have learned about their topics.

End-of-the-semester evaluations have been very positive, despite occasional grumbling that the course should carry four, rather than three, credits. The most frequent comments by the students are that the course has trained them to write efficiently; that their grades for writing in other courses have improved; that because the class was small (seventeen people), it provided a rare opportunity for students in different disciplines to work with and learn from each other; and that they would recommend the course to others.

COMMUNICATIONS AS PART OF ENGINEERING COURSE WORK

Every semester, each communications instructor works with at least one engineering course. When the arrangement has worked well, it often has been continued in subsequent terms.

The program has been affiliated with a wide range of technical courses; examples are Chemical Engineering Laboratory (Chemical Engineering 432), Structural Behavior (Civil and Environmental Engineering 371), Electrical Laboratory I—better known as Superlab (Electrical Engineering 315), Mechanical Engineering Laboratory (Mechanical and Aerospace Engineering 427), and Computerized-Instrumentation Design (Applied and Engineering Physics 264).

For Computerized-Instrumentation Design, for example, Adams worked first with Frank Wise and then with Donald Bilderback, a staff scientist at the Cornell High Energy Synchrotron Source, who taught the course this spring. Adams and Bilderback designed the writing assignments, and Adams discussed them with the class both before they were due and after they had been returned. Adams also met regularly with Bilderback and the teaching assistants—who did the actual grading—to discuss grading criteria and techniques.

Mixed among all the purely technical courses in the college are courses that are concerned with nontechnical aspects of engineering, and we have worked with a number of these. For example, when Ronald Kline of the electrical engineering faculty decided to substitute short papers for the quizzes and exams he had previously required in his course Technology in Western Society (Engineering 250), he and I derived writing assignments from the course readings and lectures. I attended class throughout the semester, and Kline and I each led regularly scheduled discussion sessions with half of the class.

Hubbard and Youra worked this past semester with Cultural Diversity in the Engineering Workplace (Engineering 355), which is coordinated by Edwin Gordon, the director of the engineering advising office. The course addresses the changing demographics of the profession, in which cultural diversity (and the number of

Left: The Engineering Communications Program participated in the college's new course Cultural Differences in the Engineering Work Environment. Steven Youra and Susan Hubbard are shown at a planning session with the course coordinator, Edwin Gordon (at left), director of advising at the college.

The course addresses several current issues in engineering education, Gordon said. One is the need to prepare engineers to function well in a profession that is becoming more culturally diverse and operates in an increasingly complex, international context. Accommodation of women engineers in the profession is another issue considered in the course. Writing assignments are included as a means of stimulating thought and expression about the course topics.

"The purpose is to make Cornell engineering graduates—men and women of all races and cultural backgrounds—better able to lead in the already changed work world," Gordon said.

Weekly lectures by specialists in various fields are followed by small-group discussion. Topics include demographic and economic changes; issues affecting women; and customs, values, and beliefs of Hispanic Americans, African Americans, and Asian Americans.

Gordon pointed out that this course complements the college's Engineering Minority Programs, which include efforts to build interest in engineering among precollege minority students *(see page 12).*

women) is rapidly increasing. The focus in the course is on understanding various cultures and appreciating the benefits of diversity. The students attended weekly lectures by people from a wide range of academic areas, including women's studies, industrial and labor relations, Africana studies, and linguistics. After each lecture, the class broke into four discussion groups—led by Hubbard, Youra, Gordon, and the guest speaker. Weekly writing assignments, alternately informal and formal, drew on the lectures and the subsequent discussions.

The pedagogical rationale for including writing in engineering courses is straightforward: when students write regularly, they become increasingly flexible as writers and thinkers. Frequent writing strengthens an awareness of issues central to effective communication.

Our students typically deal with writing as freshmen, either in a writing course per se or in a course that has writing as an important feature. Usually they take no more writing courses in their time at Cornell. Thus, when an engineering course requires them to write, they are likely to flounder. It is clear that our students can profit from both concentrated instruction in the use of words, as in courses such as Engineering 350, and sustained practice, as in the courses that train them to be engineers.

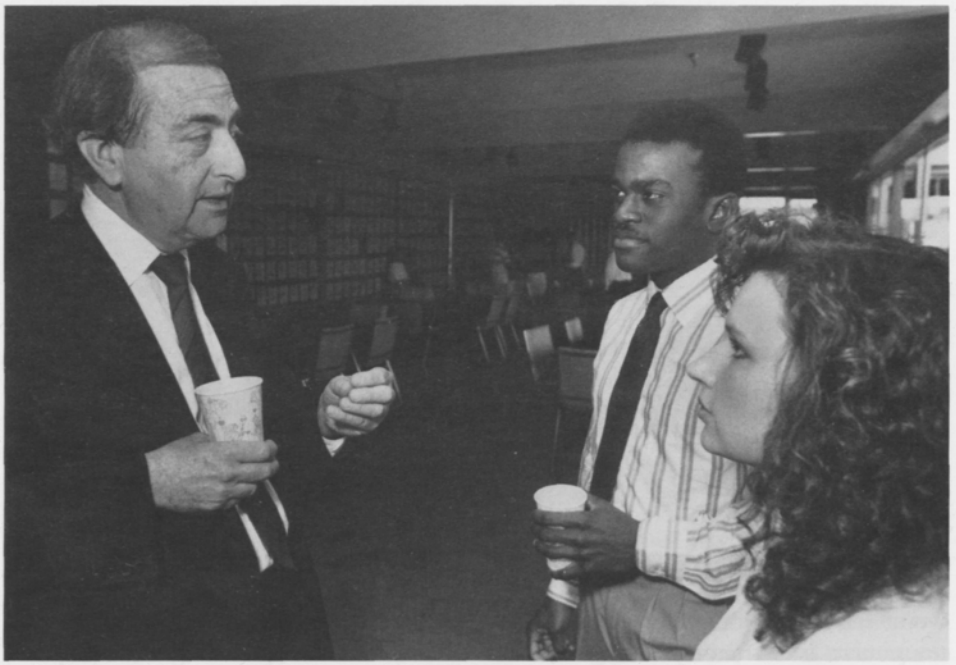
Another benefit of including writing in engineering classes is the students' sharpened understanding of course material. Faculty members have reported this result time and again. When a student struggles to articulate information that he or she understands mathematically, mistaken assumptions disintegrate in the process. Moreover, instructors and teaching assistants can see in students' writing precisely where misunderstandings have occurred. For instance, Mary Sansalone of the civil and environmental engineering faculty has required her students to submit journals as well as formal papers because journals reveal so much about the writers' grasp of the course material.

BEYOND SPECIFIC COURSE WORK: A PROGRAM WITH MANY FACETS

The work of the Engineering Communications Program goes beyond the classroom. For example, Adams is preparing a companion writing text for a mechanical engineering laboratory course. This spring Hubbard conducted three workshops at a Society of Women Engineers conference. Youra works with the college's new training program for teaching assistants, since TAs are often the people who administer writing assignments. He has also judged

Right: Winners of an essay-writing competition were honored at an Engineering Communications Program reception this spring. Prizes were awarded by Stephen Russell of the engineering-consulting firm High-Point Schaer, which sponsored the competition. Here Russell talks with Neville Rhone, Jr. '91, who won honorable mention, and Jennifer Blair '92. Russell, a Cornell graduate (B.A. 1960, M.B.A. 1961) is United States chair of High-Point Schaer.

The $1,000 first prize in the competition was awarded to Michael Souryal, a senior in electrical engineering, who wrote on "Cultural Diversity in the Work Environment". The second prize of $500 was awarded to Janet Hufnagel, a junior computer-science major, who wrote on "Using Computers to Control Environmental Pollution". The essays entered in the contest could be on either an engineering solution to a social or environmental problem, or cultural diversity in the engineering workplace. The winning essays will be published in High-Point Times, *the sponsor's international newsletter.*



Right below: Attending the reception were members of the program's recently formed alumni advisory council, as well as Engineering Communications Program faculty members and a number of their students. Left to right are John Voellmicke '91, council member Roger Berman '70, faculty member David Adams, Nalini Deonarine '91, and Janet Hufnagel '91 (a winner in the essay competition).

the undergraduate essay competition. I am an adviser to the *Cornell Engineer*, an undergraduate magazine, which recently hosted the annual national meeting of Engineering College Magazines Associated.

And although the program's primary responsibility is with undergraduate education, the work extends "down" to the pre-college level and "up" to graduate curricula: Youra participates in the Cornell Young Scholars program for high school students from minority backgrounds (see the article on page 12), and he lectures and

Left: Penny Beebe leads a discussion in her spring-term Engineering Communications seminar. Each section in the course has about seventeen students.

conducts workshops on communications in Master of Engineering classes.

We steadily increase the usefulness of our program through the exchange of ideas at educational conferences and through discussions with people from other engineering schools that are establishing writing programs. We are expanding our contacts with industrial organizations; corporate engineers are invited to visit our classes on occasion, and we have visited company sites. An important recent development is the establishment of the program's advisory council, whose members are Cornell engineering graduates.

As development of the Engineering Communications Program continues, our hope is that we will be able to work with every department. And besides working directly with specific classes, we plan to offer faculty seminars on how to incorporate writing and oral presentation into a wide range of engineering courses. Another plan is to establish a writing center, staffed by peer tutors, that can support and extend the writing done in engineering classes.

Possibilities for shorter courses of our own are suggested in course evaluations and emerge during class discussions. We have found that students are eager for contact with professionals outside Cornell; that they appreciate information about historically important engineers, scientists, and technologies; and that they love to discuss situations in which decision-making or the communication of information is a pivotal factor (for example, in contract negotiations, departmental reorganizations, disagreements about product design, or the resolution of ethical dilemmas). These areas of interest could be themes for what might be called "topics" courses.

Moreover, certain components of Engineering 350 could be the substance of separate courses. The unit on graphics could be an independent listing; it would then be able to focus on the analysis of sophisticated visual representation of ideas and data. And oral presentation, which occupies several weeks of the semester, could be the substance of an independent course, freeing 350 to focus exclusively on writing (decidedly the weakest and least easily developed of our students' skills).

Within a short time, Engineering Communications has taken its place as part of the college's undergraduate program. Cornell engineers who have both technical and communications skills will be well prepared for leadership in their profession.

Penny Beebe holds a Cornell M.F.A. degree in writing. Before coming to the engineering college, she developed and directed an interdepartmental writing center at the University of Northern Iowa.

CO-OP: A VINTAGE PROGRAM FOR TOMORROW'S ENGINEERS

by Linda Van Ness

Like a fine wine, Cornell's Engineering Cooperative Program has gotten better with age. The idea of a special program in which students can combine on-the-job experience with classroom study has been around for a long time; the first co-op program in the United States began in 1906. Today some 200,000 students from more than a thousand schools across the nation participate in cooperative education each year. At Cornell, over one-fourth of the engineering undergraduates become co-op students.

The co-op idea has grown and prospered because the rationale behind it remains valid. When Everett Strong started Cornell's program in 1946, he said, "The Plan is a *concept of education* which recognizes that an engineer cannot be made on a college campus alone; that eventually he must function in the actual environment of industry; and that he can direct his study efforts in school to better advantage when he understands that environment through his own experience in it." Today we would say "he or she", but no other changes are needed. The job market is different than it was in 1946, but co-op experience is still one of the best ways to prepare to enter it.

HIGH EXPECTATIONS FOR TODAY'S ENGINEERS

Over the years, the complexity of technology has increased dramatically, and manufacturing has become more automated. As a consequence, the fields in which engineers can choose to specialize are more numerous and the things they are called upon to do are more diverse. Today's engineers must have top-notch technical skills, keep up with computer innovations, and be aware of the latest advances in manufacturing methods.

The context of engineering has expanded too. As Japan, Korea, and newly industrialized countries such as Brazil enter the marketplace, the United States and Europe are losing their monopoly on the production of manufactured goods. This means that engineers are not only expected to contribute to the competitiveness of the company they work for, but also to the competitiveness of their nation in a world economy.

At the same time, corporations have grown larger and many have opened branches in several different countries. Engineers who work for multinational corporations must be alert to the needs of an international market and the problems of a multicultural workplace. They should have good interpersonal skills, know how to communicate well, and be aware of current management techniques.

The need for better-prepared engineers is exacerbated by a decline in the number of young people choosing engineering as a profession. The number of bachelor's degrees awarded in engineering dropped from a national high of 78,000 in 1986 to 69,000 in 1989. Unless this trend is reversed, a serious shortage of engineers is predicted by the year 2000.

CO-OP'S CONTRIBUTION TO ENGINEERING EDUCATION

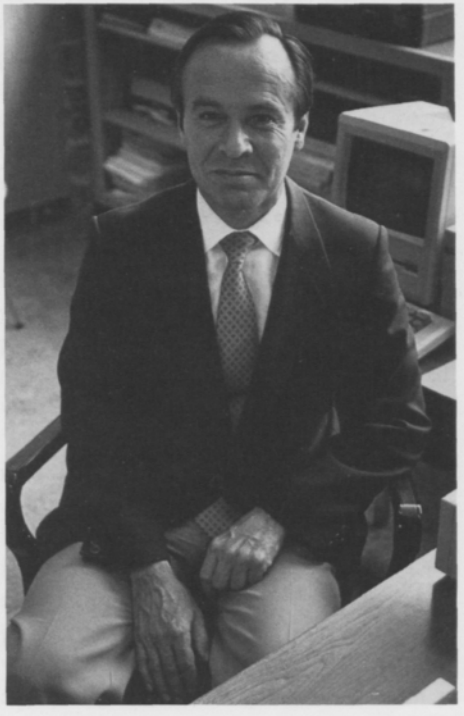
How can Cornell and its Engineering Cooperative Program help to provide more engineers who are well prepared for professional practice?

The engineering undergraduate curriculum ensures technical competence, and initiatives such as the Engineering Communications Program (see page 20) and a new course on cultural diversity in the workplace (pages 22–23) are making the curriculum more relevant to today's needs. In addition, undergraduates can acquire

Left: This early group of co-ops is noticeable for its small size and the absence of women. The photograph was taken in 1949, when the program was in its third year. The professor in the front row is Everett M. Strong, the first director.

Left below: Four program directors got together for a group photograph in 1977. The late Everett M. Strong, professor of electrical engineering, who was director from 1947 to 1967, is seated at left, next to Robert N. Allen, a professor of operations research and industrial engineering, now emeritus, who served as director until 1977. Standing are Donald F. Berth (at left) and Richard H. Lance, codirectors until 1980. Berth, then director of special projects at the college, is now a vice president at Worcester Polytechnic Institute. Lance is a Cornell professor of theoretical and applied mechanics.

Below: The current director is K. Bingham Cady, associate dean for college affairs and professor of nuclear science and engineering.



some familiarity with how engineering is actually practiced through various programs offered by or through the college or university. Some of these programs arrange for short stays at industrial sites or provide summer job opportunities. Through academic or extracurricular activities, students can attend seminars with people from industry and have opportunities to participate in "hands-on" projects that involve professional engineers. But when it comes to exposure to the "real world", the co-op program does it best. A co-op student spends a full semester in a paid job in industry, plus one or two summers with the same company.

Vigorous recruitment among minorities and women will help to alleviate the shortage of engineers. Minority groups are growing as a percentage of the overall population, and by the year 2000 40 percent of the college-age population will be African American or Hispanic American. Also, women are entering the labor force in increasing numbers, and more opportunities are opening up for women in engineering. At Cornell the engineering college has an active program to recruit and retain minorities (see page 12), and efforts are made to interest more women in becoming students. But the co-op program also has a role here. The real-world aspect of cooperative education can help attract engineers from the underrepresented groups, and facilitate their entry into the profession.

". . . when it comes to exposure to the 'real world', the co-op program does it best."

One effective way of interesting high school students in engineering at Cornell is to bring them in contact with co-op participants. Co-ops are highly effective exponents of the career opportunities that can be found in engineering; they are enthusiastic about what they are doing and constantly talk about their experiences. When they speak to groups of high school students at events sponsored by alumni, they make a big impression.

In recognition of the internationalization of industry, the co-op program has recently begun placing a few students overseas. In a spirit appropriate to a program dedicated to cooperation, students are learning to work *with* foreign industries rather than *against* them. In recent years two students worked in Japan, two in Venezuela, and one in Germany. The Japanese company, Nissan, wants to increase its interaction with American universities and students, and the co-op program is responding by placing two more students with Nissan this fall.

BIG BENEFITS FOR PARTICIPATING COMPANIES

In the context of rapidly changing technology, the advantages of the co-op program for employers are greater than ever. Industry is constantly having to find people with new skills or to retrain current employees, and the cost of both recruiting and retraining is considerable. Making a place for co-op students is a proven, cost-effective way to recruit candidates with up-to-date skills for permanent employment. Companies know that participating in the co-op program is a way to get a head start in recruiting the best college graduates. They are also aware that co-op students who are subsequently hired as regular employees become productive sooner than other new employees because they require less training, and are more likely to stay with the company.

Participation in the co-op program has a further advantage for many companies: it opens a channel of communication between them and the university. Opportunities for serious discussion about engineering education occur when industrial

Above: The process of placing co-ops in jobs begins with a fall meeting of company representatives and prospective student employees. On the opening evening students visit booths set up and manned by the company people. Individual interviews are conducted the following day.

Below: During the 1989 fall term, Louis Lanzerotti had a co-op job at Emerson Power Transmission in Ithaca. One assignment was to help manufacturing engineer Bob Tompkins (at left) update machine layouts to match new locations of several pieces of equipment.

representatives come to campus to interview prospective co-op students, and also when faculty members make site visits to students during their work assignments. On these occasions people from industry can bring people in academia up to date on the kinds of instruction that will best prepare young engineers to step into the workplace. The direct, informal contact can also foster the exchange of ideas about research and possible cooperative efforts.

LEARNING AND EARNING: THE STUDENTS' PERSPECTIVE

While the college is concerned about the national health of the engineering profession and the welfare of the nation's industrial companies, our primary interest is in the education and welfare of our students. Those of us who work with the Engineering Cooperative Program strongly believe that it provides a valuable part of an engineering education, and since it is a very popular program with students, they evidently agree. About 40 percent of the sophomore class signs up for job interviews. In the year just ended, 310 students were enrolled in the co-op program.

Part of the attraction is that they can spend eight months of their college career working at a real engineering job and still graduate with their class. Of course, the professional-level salary for those eight months of work in industry is an added valued benefit.

And beyond the experience and the pay is the help the co-op experience can give in clarifying interests and career objectives. Many co-ops coming back from their term in industry say that they have a clearer idea of how they wish to shape their academic programs, and of what kind of work they would like to do, and where. They have had a chance to observe professionals in a

Mary-Lou Smulders: A Co-op Student of the '90s

In the early days of the co-op program at Cornell, all the participants were men. Back then, women did not become engineers. Teachers, nurses, or librarians, maybe. But not engineers. Now all that has changed, and women are out there doing "a man's job", as Cornell women co-ops ably demonstrate.

Take the case of Mary-Lou Smulders, a mechanical engineering major who is graduating this spring. She entered the competition for co-op positions and was invited to work for the Mobil Oil Corporation, which assigned her to its Exploration and Production Division. Her first task, in Louisiana, involved writing research projects for a study of the electrical efficiency of a pumping system at one oil field and of compressor capacity at another field. She was then transferred from Facilities ("where you save the money") to Operations ("where you make the money").

In this assignment she was asked to analyze the problem with five oil wells that were either not producing at all or producing below expectation, and to propose a solution. Mobil owns the wells, but subcontracts the jobs involved in running them. This meant that Smulders had to coordinate activities with as many as five or six different companies for each oil well. She was given a $50,000 budget, and this, she says, "is where the fun began—from haggling about the prices of bridge plugs, pump trucks, and services, to being taken out to lunch almost every day."

After all the costs were set, she would "write up a proposal that included a well history, a description of the problem, a suggested solution, a detailed account of the procedure, and the results of a cost-and-profit analysis program run on the Mobil mainframe." The proposal was then sent around for additional input.

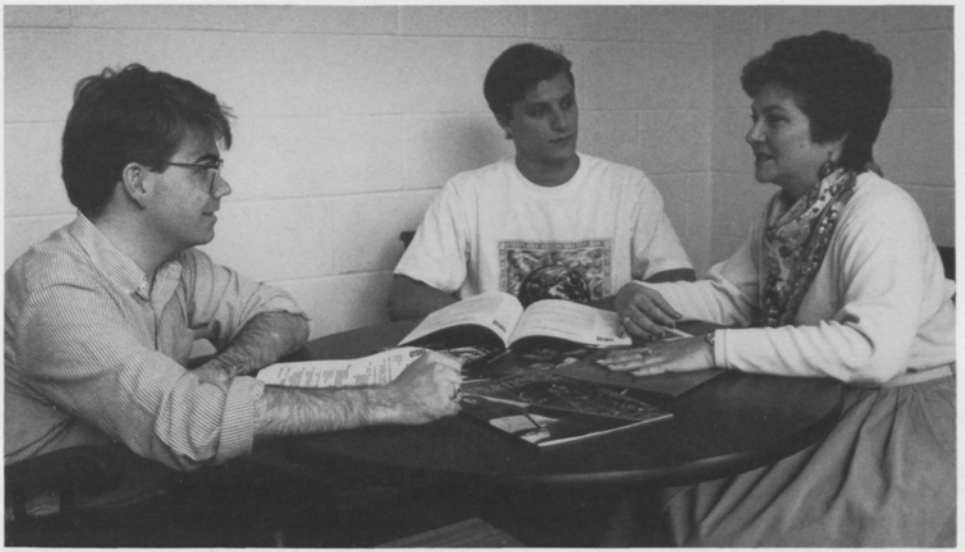
After it had been approved, the actual work on the well began. Smulders continued as project engineer during this phase, sometimes flying out to off-shore oil rigs in an amphibious plane. She worked with the field foreman, the rig supervisor, and other engineers to oversee the well workover and solve unexpected problems.

In assessing her co-op experience, Smulders wrote, "I was exposed to three very different but essential aspects of a business. First, I worked an engineering problem out on paper, using theories and equations to determine pressures, densities, temperatures, and flow rates. Next, I made deals and wrote contracts for large sums of money, thereby gaining valuable business knowledge. Finally, I helped oversee the actual work, learning to manage and work with others to get the job done."

After a second work period in Bakersfield, California, where she carried out two "important and necessary tasks that would otherwise have been performed by an experienced full-time operations engineer", she returned to Cornell for her final semester. In light of her experience with Mobil, she has realized that she wants to go on with her education and earn an M.B.A. She has been accepted by Erasmus University in the Netherlands, an elite institution that seldom takes candidates without several years of work experience. And Mobil, apparently convinced that a woman *can* do a "man's job", has asked her to keep in touch.

Below: Mary-Lou Smulders on the co-op job at Mobil.

Right: Linda Van Ness, the co-op program coordinator, often has an office full of students who drop by to consult the staff, peruse literature about the program and the participating companies, and read reports by co-ops who have completed job assignments. Those in the photo are Charles Webb '90 (at left) and Federico Larco '91.



variety of roles, as well as "try out" potential permanent employers.

HOW THE PROGRAM WORKS —AND WHY

Although the co-op program continually adapts to changing situations in industry and the profession—that is the key to its success and vigor—the way it works has stayed essentially the same over the years. The number of engineering fields in which positions are available has grown from two (electrical engineering and mechanical engineering) in 1947 to eight today, and the company sites have increased from one to more than one hundred, but on-the-job experience is still the basic element. Although computers now help with scheduling, there is still a big spring event when company representatives come to campus to interview students interested in co-op jobs. Matching of employers and employees is more complicated than it used to be and the procedure has become more sophisticated, but the principle of mutual selection still governs. Students and faculty continue to enjoy the extra contact that participation in the co-op program brings, and the annual picnic remains a high point of the year.

Student participation in the program generally follows a sequence that has stayed essentially the same over the years. Those who qualify (they must be in the upper half of their class academically) and wish to enroll go through the process of securing a job assignment. They begin the program in the summer following their sophomore year by taking the first half of their junior-year courses in specially scheduled classes. The first work period at the company site extends from about Labor Day through mid-January. The students are back on campus for the spring term, completing their junior year of study, and then return to their companies for the summer. Employment at the same company the summer after graduation is an option.

A major reason for the enduring success of the program is that it accomplishes much more than just placing students in jobs. Work assignments are selected with the learning experience in mind, and the student's progress is monitored by a faculty member in consultation with the industrial supervisor. Each co-op prepares written reports about the job experience, and these reports are available to other students, to help in decisions about what kind of job to seek with what company.

The Engineering Cooperative Program is the most popular option available to undergraduates. Faculty members have long appreciated the program's value, and support it through teaching in the special summer session, making site visits, and promoting it among their students. Support from industry also continues, and grows, because companies appreciate its value to them. In fact, through all the deep-rooted changes in society and industry in recent history, co-op experience has continued to be an excellent component of the education of an engineer. The program flourishes because it works.

Linda Van Ness has been coordinator of the Engineering Cooperative Program at Cornell since 1984. At the College of Engineering she serves on the Committee on the Status of Women in Engineering and the Human Resources Advisory Committee. She was co-chair of the Cornell Employees' United Way Campaign.

She is a member of the Cooperative Education Association and the New York State Cooperative Experiential Education Association.

REGISTER

Five members of the College of Engineering faculty will retire as professors, emeritus at the end of this academic year. All of them have been at Cornell since the 1940s or early 1950s.

■ *Ralph Bolgiano, Jr.* holds four Cornell degrees in electrical engineering and has spent thirty-two years on the faculty.

After earning the B.S. in 1944, he served as an instructor in the Army Signal Corps during World War II and then returned to Cornell as an instructor and graduate student; he earned the B.E.E. degree in 1947 and the M.E.E. in 1949. For the next five years he worked at the General Electric Company as a development engineer in television and as supervisor of the communications theory group. Then he began doctoral studies at Cornell and served as a research assistant until the degree was awarded in 1958. He rejoined the Cornell faculty at that time.

Bolgiano's specialty is tropospheric radiophysics, and at the university he has been associated with the Center for Radiophysics and Space Research as well as the School of Electrical Engineering. His research has centered on turbulent flow in the troposphere, the stratosphere, and the ocean, and on the highly anisotropic structure that results. Field work by his group produced some of the first evidence of the anisotropy of atmospheric microstructure at a scale of the order of one meter.

Bolgiano

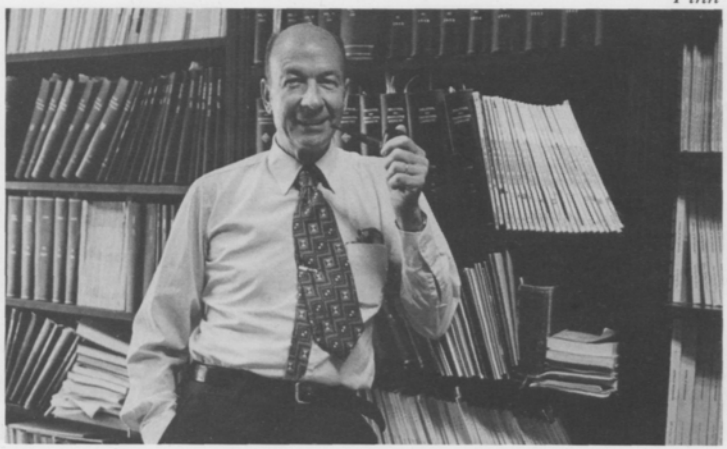
Bolgiano was Cornell's scientific representative on the Board of Trustees of the University Corporation for Atmospheric Research during its formative years, from 1961 to 1971. From 1960 to 1970 he was a member of the URSI-IUGG Interunion Commission on Radiometeorology, and served as president of that group from 1967 to 1970. He has been a Guggenheim scholar at the Université de Provence, France, a visiting scientist at the Appleton Laboratory, United Kingdom, and a visiting senior research associate at the University of Colorado.

At Cornell in 1983 he was recognized for "inspirational teaching and interaction with students" with a special award.

Bolgiano is a senior member of the Institute of Electrical and Electronics Engineers, a fellow of the American Association for the Advancement of Science, and a member of the American Meteorological Society and the American Geophysical Union.

He plans to continue to pursue his interest in the irregular structure of stably stratified atmospheric fluids, an activity "interspersed now and then with a bicycle ride around the Finger Lakes district".

Finn



Fisher

■ *Robert K. Finn* is also a Cornell alumnus (B.Chem. 1941, and Chem.E. 1942) as well as a member of the faculty. He has been at Cornell's School of Chemical Engineering since 1955.

After completing his studies at Cornell, Finn was a research engineer at Merck and Company for four years, and then entered graduate school at the University of Minnesota, where he received a doctorate in chemical engineering and microbiology in 1949. Subsequently he taught at the University of Illinois at Urbana, where he established a program in bioengineering.

His research in recent years has concerned the use of living cells to convert renewable resources into more valuable chemicals, and with methods of treating industrial wastewaters. He has also worked in the areas of microbial kinetics, fermentation processes, and enzymic conversions of alcohol and sugar for industrial appplications. He has been active as a consultant to a number of chemical industries.

Finn was a Fulbright scholar in Stuttgart, Germany, in 1962 and a Guggenheim fellow at the Institute of Microbiology in Zürich, Switzerland, in 1975. In 1982–83 he was a guest research professor at the Institute for Biotechnology in the Nuclear Research Center, Jülich, Germany.

He is a fellow of the American Association for the Advancement of Science, and in 1982 he received the Van Lanen Award of the American Chemical Society's Division of Microbial Chemistry and Technology. He belongs to the honorary society Sigma Xi, as well as a number of professional societies, and he has served on the editorial boards of several journals.

He will be staying in Ithaca after retirement, and hopes to continue several small research projects.

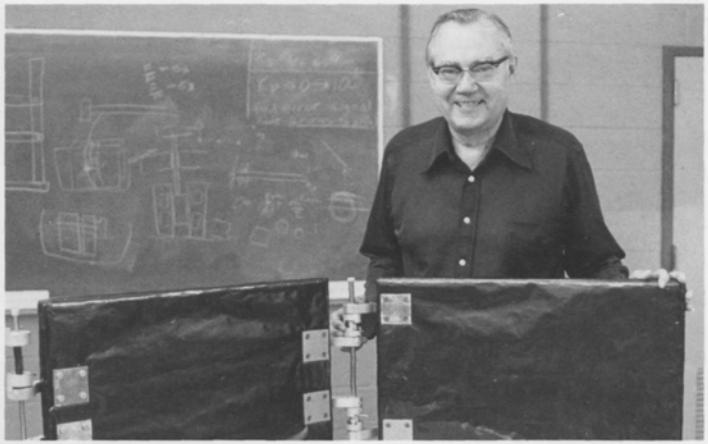
■ *Gordon P. Fisher*, a professor of environmental engineering, joined the Cornell faculty in 1948 after completing the Dr.Eng. degree at The Johns Hopkins University.

At Cornell he has served as associate dean of the College of Engineering (1960–66); first head of the Department of Environmental Systems Engineering (1966–71); director of the Water Resources Center, which he founded; and director of the Program in Urban and Regional Studies.

He earned the B.E. degree in civil engi-

Vrana

Wehe



neering at Johns Hopkins in 1942, and spent the war years doing research on military aircraft and as an officer in the Army Corps of Engineers. His early research was in structural engineering; since 1966, he has specialized in the planning and design of transportation systems. He has spent sabbatical leaves at the Pittsburgh–Des Moines Steel Company and at universities in Japan, Mexico, and Sweden.

Honors he has received include the 1962 Norman Medal of the American Society of Civil Engineers (ASCE) for his work on the structural integrity of nuclear reactors. He has held fellowships with NSF, NASA, and the Japan Society for Promotion of Science, and he was a Distinguished Visiting Scholar at the University of Hawaii.

He is a fellow of the ASCE and the American Concrete Institute, and a member of the Transportation Research Board, the Operations Research Society of America, the Paleontological Research Institution, and several honorary societies. He is a registered Professional Engineer in New York and Maryland and a consultant to the Central Japan Railway Company and the East Japan Railway Company.

■ *Norman R. Vrana*, an electrical engineering professor, has been on the faculty since 1951, when he received the Cornell M.E.E. degree.

He was awarded the B.E.E. in 1947 at New York University and served in the U.S. Navy from 1944 to 1946.

His industrial experience includes consulting and summer or sabbatical leave positions with the New York Telephone Company, the Foxboro Company, North American Aviation, the ADT Company, Hewlett-Packard, Autonetics, the Partlow Corporation, and the Hennessy Company. Also, he has been a consultant for the U.S. Army's Aberdeen Proving Ground and Frankford Arsenal.

In recent years his research interests have been in digital systems, central processor design, and microprocessor systems.

At Cornell he has served on various committees for undergraduate, graduate, and continuing education. In 1989 he received the Ruth and Joel Spira Excellence in Teaching Award from the School of Electrical Engineering.

Vrana plans to spend time on "things that have been neglected", including research on subjects of personal interest.

■ *Robert L. Wehe* began his studies in mechanical engineering at the University of Kansas, where he received the B.S. degree in 1948. Previously he had served for several years as a bombardier in the Eighth Air Force. He received the M.S. degree in 1951 from the University of Illinois, where he also served as an instructor in machine design. He joined the Cornell faculty in 1951.

Wehe has held summer positions or served as a consultant at a number of industrial companies, including Corning, Westinghouse Electric, Seneca Falls Machine, and Lycoming Aircraft.

At Cornell he has been especially active in working with Master of Engineering students on their design projects. These have included a remote-activated device (shown in the photograph) for opening solar panels on a satellite, and an autonomous Martian roving vehicle.

He is a member of the American Society of Mechanical Engineers, the Society of Automotive Engineers, the American Society for Engineering Education, and Sigma Xi.

His retirement plans include travel, and work on the use of computers in teaching design.

FACULTY PUBLICATIONS

Current research activities at the Cornell University College of Engineering are represented by the following publications and conference papers that appeared or were presented during the three-month period October through December 1989. (Earlier entries omitted from previous Quarterly *listings are included here with the year of publication in parentheses.) The names of Cornell personnel are in italics.*

■ AGRICULTURAL AND BIOLOGICAL ENGINEERING

Albright, L. D. 1989. Slotted inlet baffle control based on inset momentum numbers. *Transactions of the ASAE* 32(5):1764–68.

Datta, A. K. 1989. Interactive graphics-based software for introducing heat transfer and on-line control as applied to food thermal processing. Paper read at Winter Meeting, American Society of Agricultural Engineers, 12–17 December 1989, in New Orleans, LA.

McGechan, M. B., and *R. E. Pitt.* 1989. The rewetting of partially dried grass swaths by rain. II. Exploratory experiments into absorption and drying. *Journal of Agricultural Engineering Research* 45:69–76.

Mercurio, J. F., W. W. Gunkel, J. A. Throop, A. T. Sobel, and *D. W. Norman.* 1989. Vision-guided block-type robotic grapevine pruner. Paper read at Winter Meeting, American Society of Agricultural Engineers, 12–17 December 1989, in New Orleans, LA.

Pitt, R. E., and M. B. McGechan. 1989. The rewetting of partially dried grass swaths by rain. I. Lumped and distributed models of moisture fluctuation. *Journal of Agricultural Engineering Research* 45:55–67.

Pivetz, B., and *T. S. Steenhuis.* 1989. Pesticide, nitrate, and tracer loss in agricultural tile lines and to ground water under conventional and conservation tillage. Paper read at Winter Meeting, American Society of Agricultural Engineers, 12–17 December 1989, in New Orleans, LA.

Rehkugler, G. E. 1989. A not-so-well known aspect of bioengineering. *Interface: A Newsletter for Cornell Engineering Students* November: 6.

Selker, J. S., T. S. Steenhuis, and *J. Y. Parlange.* 1989. Preferential flow in homogeneous sandy soils without layering. Paper read at Winter Meeting, American Society of Agricultural Engineers, 12–17 December 1989, in New Orleans, LA.

■ APPLIED AND ENGINEERING PHYSICS

Bilderback, D. H. 1989*a*. CHESS, the Synchrotron Radiation Laboratory at Cornell University. *Synchrotron Radiation News* 2:19.

___. 1989*b*. Fabricating rectangular internal cooling channels in silicon x-ray monochromator optics. *Review of Scientific Instruments* 60(7):1477–78.

Bilderback, D. H., B. W. Batterman, M. J. Bedzyk, K. Finkelstein, C. Henderson, A. Merlini, *W. Schildkamp, E. B. Blum,* et al. 1989. The performance of a hard x-ray undulator at CHESS. *Review of Scientific Instruments* 60(7):1478–79.

Bilderback, D. H., C. Henderson, J. White, R. K. Smither, and G. A. Forster. 1989. Undulator heat loading studies on x-ray monochromators cooled with liquid gallium. *Review of Scientific Instruments* 60(7):1473–76.

Farmer, K. R., and *R. A. Buhrman.* 1989. Defect dynamics and wear-out in thin silicon oxides. *Semiconductor Science and Technology* 4:1084–105.

Kwong, Y. K., K. Lin, P. Hakonen, J. M. Parpia, and *M. Isaacson.* 1989. The application of reactive ion etching in producing free-standing microstructures and its effects on low-temperature electrical transport. *Journal of Vacuum Science and Technology B* 7(6):2020–24.

Lathrop, D. K., S. E. Russek, K. Tanabe, and *R. A. Buhrman.* 1989. In-situ growth of high T_c thin films. In *Science and technology of thin film superconductors,* pp. 81–90. New York: Plenum.

Millard, P. J., T. A. Ryan, W. W. Webb, and *C. Fewtrell.* 1989. Immunoglobulin E receptor cross-linking induces oscillations in intracellular free ionized calcium in individual tumor mast cells. *The Journal of Biological Chemistry* 264:19730–39.

Moffat, K., B. Batterman, D. Bilderback, W. Schildkamp, T.-Y. Teng, A. LeGrand, and *D. Szebenyi.* 1989. MacCHESS: A macromolecular diffraction resource at the Cornell High Energy Synchrotron Source. In *Proceedings, Brookhaven Symposium on Quantitative Biology,* ed. R. Sweet and A. Woodhead, p. 15. New York: Plenum.

Moffat, K., D. Bilderback, W. Schildkamp, D. Szebenyi, and *T.-Y. Teng.* 1989. Laue photography from protein crystals. In *Proceedings, Brookhaven Symposium on Quantitative Biology,* ed. R. Sweet and A. Woodhead, p. 325. New York: Plenum.

Ouyang, F., and *M. Isaacson.* 1989. Accurate modeling of particle-substrate coupling of surface plasmon excitation in EELS. *Ultramicroscopy* 31(4):345–49.

Ralls, K. S., R. A. Buhrman, and *R. C. Tiberio.* 1989. Fabrication of thin-film metal nanobridges. *Applied Physics Letters* 55:2459–61.

Ralls, K. S., D. C. Ralph, and *R. A. Buhrman.* 1989. Individual-defect electromigration in metal nanobridges. *Physical Review B* 40:11561–70.

Shin, D. H., E. J. Kirkland, and *J. Silcox.* 1989. Annular dark field electron microscope images with better than 2 Å resolution and 100 kV. *Applied Physics Letters* 55:2456–58.

Smither, R. K., G. A. Forster, *D. H. Bilderback, M. Bedzyk, C. Henderson,* and *J. White.* 1989. Liquid

gallium cooling of silicon crystals in high intensity photon beams. *Review of Scientific Instruments* 60(7):1486–92.

Tanabe, K., D. K. Lathrop, S. E. Russek, and *R. A. Buhrman.* 1989. Epitaxial Y-Ba-Cu-O thin films on MgO deposited by high pressure reactive evaporation. *Journal of Applied Physics* 66:3148.

Tangyunyong, P., T. N. Rhodin, R. Ozer, D. Batchelor, Y. T. Tan, and K. J. Lushington. 1989. Surface structure studies of silver bromide (111) and (320) using fluorescence SEXAFS. *Physica B* 158:637–39.

Theil, D. J., E. A. Stern, *D. H. Bilderback,* and *A. Lewis.* 1989. Focusing of synchrotron radiation using tapered glass capillaries. *Physica B* 158:314–16.

Tietz, L. A., C. B. Carter, D. K. Lathrop, S. E. Russek, R. A. Buhrman, and *J. R. Michael.* 1989. Crystallography of $YBa_2Cu_3O_{6+x}$ thin film–substrate interfaces. *Journal of Materials Research* 4:1072.

■ CHEMICAL ENGINEERING

Agrawal, D. C., R. Raj, and *C. Cohen.* 1989. Nucleation of flocs in dilute ceramic suspensions. *Journal of the American Ceramic Society* 72:2148.

Bringi, V., and *M. L. Shuler.* 1989. A framework for understanding the effects of immobilization on plant cells: Differentiation of tracheary elements in tobacco. Paper read at Physiology of Immobilized Cells, 10–13 December 1989, in Wageningen, The Netherlands.

Calado, J. C. G. 1989. The industrial cauldron: Art, technology, and society, 1750–1850. *Engineering: Cornell Quarterly* 24(1):28–39.

Chalam, M. K., K. E. Gubbins, and F. van Swol. 1989. Liquid crystal phase transitions in a narrow pore. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Chalmers, J. J., E.-K. Kim, J. N. Telford, E. Y. Wong, W. C. Tacon, *M. L. Shuler,* and *D. B. Wilson.* 1989. Effects of temperature on *E. coli* overproducing ß-lactamase or human epidermal growth factor. *Applied and Environmental Microbiology* 56:104–11.

Chalmers, J. J., M. L. Shuler, and *D. B. Wilson.* 1989. A simple membrane reactor to obtain high cell density and plasmid encoded protein production from *Escherichia coli*. *Biotechnology Techniques* 4(2):73–78.

Clark, P. A. 1989. Optimizing process models in the presence of phase transitions. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Clark, P. A., and *S. Mohindra.* 1989. A negotiation framework for chemical process operations. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Dems, B. C., P. D. Krasicky, and *F. Rodriguez.* 1989. Quantitative analysis of laser interferometer waveforms obtained during oxygen reactive-ion etching of thin polymer films. In *Polymers in microlithography,* ed. E. Reichmanis, S. A. MacDonald, and T. Iwayanagi, pp. 234–51. Washington, DC: American Chemical Society.

Dems, B. C., and *F. Rodriguez.* 1989. Local heating effects during the argon and oxygen RIE of polymer films. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Dems, B. C., F. Rodriguez, C. M. Solbrig, Y. M. N. Namaste, and *S. K. Obendorf.* 1989. Reactive ion etching of polymer films. *International Polymer Processing* 4:183–87.

Engstrom, J. R., D. J. Bonser, and T. Engel. 1989*a*. Effect of coincident ion bombardment on the oxidation of Si(100) by atomic oxygen. *Applied Physics Letters* 55:2202–04.

___. 1989*b*. Kinetics and mechanisms of ultrathin oxide formation on silicon surfaces. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Finn, R. K. 1989*a*. New challenges in metabolic engineering. In *Bioprocess engineering: The first generation,* ed. T. K. Ghose, pp. 20–29. Chichester, England: Ellis Horwood.

___. 1989*b*. Some origins of biotechnology. *Swiss Biotechnology* 7(4):15–17.

Finn, R. K., and P. Präve, eds. 1989. *Biotechnology focus.* vol. 2. New York: Hansen.

Fu, J., A. P. Togna, D. B. Wilson, and *M. L. Shuler.* 1989. The continuous overproduction and excretion of a plasmid-encoded protein by *E. coli* in multi-stage chemostats. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Gubbins, K. E., and *A. Z. Panagiotopoulos.* 1989. Molecular simulation. *Chemical Engineering Progress* 85:23–27.

Hammer, D. A. 1989. Transport analysis of receptor-ligand interactions. In *Chemical engineering problems in biotechnology,* ed. *M. L. Shuler,* pp. 81–106. New Technology Education Series, vol. 1. New York: American Institute of Chemical Engineering.

Koch, D. L. 1989. On hydrodynamic diffusion and drift in sheared suspensions. *Physics of Fluids A* 1:1742–45.

Koch, D. L., and E. S. G. Shaqfeh. 1989. The instability of a dispersion of sedimenting spheroids. *Journal of Fluid Mechanics* 209:521–42.

Malhotra, S., B. C. Dems, F. Rodriguez, Y. M. N. Namaste, and *S. K. Obendorf.* 1989. Negative resist systems for e-beam lithography. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Merrill, R. P. 1989. Dynamics of precursor adsorption. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Panagiotopoulos, A. Z. 1989. Molecular simulation of phase equilibria. Paper read at 1989 Annual Meeting, Council for Chemical Research, 1–3 October 1989, in Parsippany, NJ.

Panagiotopoulos, A. Z., and *M. R. Stapleton.* 1989. The Gibbs method for calculating phase equilibria by simulation. *Fluid Phase Equilibria* 53:133–41.

Patel, S. K., F. Rodriguez, and *C. Cohen.* 1989. Mechanical and swelling properties of polyacrylamide gel spheres. *Polymer* 30:2198–203.

Russo, M. J., and P. H. Steen. 1989. Shear stabilization of the capillary breakup of a cylindrical interface. *Physics of Fluids A* 1(12):1926–37.

Shuler, M. L. 1989*a*. Bioprocess integration and control. Paper read at Department of Energy Workshop

on Bioprocessing Research for Energy Applications, 2–4 November 1989, in Washington, DC.

___. 1989*b*. Plant, mammalian and insect cell cultures: Similarities and differences. Paper read at 1989 International Chemical Congress of Pacific Basin Societies, 17–22 December 1989, in Honolulu, HI.

Shuler, M. L., T. Cho, T. Wickham, O. Ogonah, M. Kool, D. A. Hammer, R. R. Granados, and *H. A. Wood.* 1989. Bioreactor development for production of viral pesticides or heterologous proteins in insect cell cultures. Paper read at Biochemical Engineering VI (Engineering Foundation) conference, 2–7 October 1989, in Santa Barbara, CA.

Streett, W. B. 1989. On the preparation of engineers for their role in society: Introductory comments by the dean. *Engineering: Cornell Quarterly* 24(1):2–3.

Tan, Z., and *K. E. Gubbins.* 1989. Fluid mixture behavior in micropores. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

Wickham, T. J., D. A. Hammer, T. Brosenne, M. L. Shuler, H. A. Wood, and *P. R. Granados.* 1989. Effects of surface chemistry on receptor-mediated viral attachment to cell surfaces. Paper read at Annual Meeting, American Institute of Chemical Engineers, 5–10 November 1989, in San Francisco, CA.

■ CIVIL AND ENVIRONMENTAL ENGINEERING

Beech, J. F., *F. H. Kulhawy,* and *C. H. Trautmann.* 1989. Influence of geologic development on horizontal stress in soil. In *Foundation engineering: Current principles and practices,* ed. *F. H. Kulhawy,* pp. 43–57. New York: American Society of Civil Engineers.

Deierlein, G. G., T. M. Sheikh, J. A. Yura, and J. O. Jirsa. 1989. Beam-column moment connections for composite frames. II. *Journal of Structural Engineering* 115(11):2877–96.

Dick, R. I. 1989*a*. Mechanisms of compressible cake filtration. *Fluid/Particle Separation Journal* 2:123.

___. 1989*b*. Some practical implications of thickening theory. In *Proceedings, Annual Technical Conference on Filtration and Separation,* ed. G. E. Weismantel, pp. 351–54. Kingwood, TX: American Filtration Society.

Hsieh, S. H., G. Deierlein, W. McGuire, and *J. F. Abel.* 1989. *Technical manual for CU-STAND.* Structural engineering report no. 89–13. Ithaca, NY: Cornell University.

Hsieh, S. H., and *Y. Zhao.* 1989. *Programmer's manual for CU-PREPF, CU-STAND, and CU-QUAND.* Structural engineering report no. 89–15. Ithaca, NY: Cornell University.

Miura, F., H. E. Stewart, and *T. D. O'Rourke.* 1989. Lateral spreading effects on pile foundations. In *Proceedings, 2nd U.S.–Japan Workshop on Liquefaction, Large Gound Deformation, and Their Effects on Lifeline Facilities,* ed. *T. D. O'Rourke* and M. Hamada, pp. 295–307. Buffalo, NY: National Center for Earthquake Engineering Research.

Orchant, C. J., *F. H. Kulhawy,* and *C. H. Trautmann.* (1988.) *Critical evaluation of in-situ test methods.* Report EL–5507, vol. 2. Palo Alto, CA: Electric Power Research Institute.

Philpot, W. D., and *A. Vodacek.* 1989. Limits to the use of laser-induced fluorescence for remote detection of hydrogen ion, aluminum, and dissolved organics matter. *Remote Sensing of Environment* 29:51–65.

Sansalone, M., and N. J. Carino. 1989. Finite element studies of the impact-echo response of layered plates containing flaws. In *International advances in nondestructive testing,* ed. W. McGonnagle. New York: Gordon-Breach Science.

Sheikh, T. M., *G. G. Deierlein,* J. A. Yura, and J. O. Jirsa. 1989. Beam-column moment connections for composite frames. I. *Journal of Structural Engineering* 115(11):2858–75.

Tasker, G. D., and *J. R. Stedinger.* 1989. An operational GLS model for hydrologic regression. *Journal of Hydrology* 111:361–75.

Trautmann, C. H. (1988*a*.) *Geotechnical testing of model foundations.* Institute for Foundation Engineering and Construction Management report no. 18, pp. 71–84. Berlin, West Germany: Technical University of Berlin.

___. (1988*b*.) *New method for control of the vibroflotation process.* Research report no. 9981. Munich, West Germany: Technical University of Munich.

Trautmann, C. H., and *F. H. Kulhawy.* (1988.) Uplift load-displacement behavior of spread foundations. *Journal of Geotechnical Engineering* 114(2):168–84.

___. 1989*a*. *CUFAD+: A computer program for compression and uplift foundation analysis and design with expert system data advisor.* Report no. EL–6583–CCML. Palo Alto, CA: Electric Power Research Institute.

___. 1989*b*. Use of knowledge-based front ends in civil engineering design programs. In *Proceedings, 7th National Conference on Microcomputers in Civil Engineering,* ed. W. E. Carroll and D. S. Leftwich, pp. 1–4. Orlando, FL: University of Central Florida.

Trautmann, C. H., F. H. Kulhawy, and V. J. Longo. 1989. CUFAD: A computer program for compression and uplift foundation analysis and design. In *Foundation engineering: Current principles and practices,* ed. *F. H. Kulhawy,* pp. 691–705. New York: American Society of Civil Engineers.

Zhao, Y., G. Deierlein, J. F. Abel, and *W. McGuire.* 1989. *Technical manual for CU-QUAND.* Structural engineering report no. 89–14. Ithaca, NY: Cornell University.

■ COMPUTER SCIENCE

Akl, S. E., *D. Gries,* and I. Stojmenovic. 1989. An optimal parallel algorithm for generating combinations. *IPL* 33:135–39.

Bilardi, G. 1989. Merging and sorting networks with the topology of the omega network. *IEEE Transactions on Computers* 38(10):1396–1403.

Chew, L. P. 1989. There are planar graphs almost as good as the complete graph. *Journal of Computer and System Sciences* 39(2):205–19.

Cooper, R., and *K. Birman.* 1989. Supporting large scale applications on networks of workstations. In *Proceedings, 2nd Workshop on Workstation Operating Systems,* pp. 25–28. Washington, DC: IEEE Computer Society Press.

Gries, D., et al. 1989. Computer languages. In *Computer science: Achievements and opportunities,* ed. *J. E. Hopcroft* and *K. W. Kennedy,* pp. 15–28. Philadelphia, PA: SIAM.

Gries, D., and D. Marsh. 1989. The 1987–88 Taulbee survey. *Communications of the ACM* 32(10):1217–24; *Computer* 22(11):49–56.

Hirsch, M. D., C. H. Papadimitriou, and *S. A. Vavasis.* 1989. Exponential lower bounds for finding Brouwer fixed points. *Journal of Complexity* 5:379–416.

Hoffmann, C. M., *J. E. Hopcroft,* and M. Karasick. 1989. Robust set operations of polyhedral solids. *IEEE Computer Graphics and Applications* 9(6):50–59.

Salton, G. 1989. Information retrieval using phrase generation methods. Paper read at 1989 American Society for Information Science Conference, 3–5 November 1989, in Washington, DC.

Vavasis, S. A. 1989. Gaussian elmination with pivoting is P-complete. *SIAM Journal of Discrete Mathematics* 2:413–23.

■ ELECTRICAL ENGINEERING

Agrawal, R., D. Teneketzis, and *V. Anantharam.* 1989. Asymptotically efficient adaptive allocation rules for controlled Markov chains: Finite parameter space. *IEEE Transactions on Automatic Control* 34(12):1249–59.

Anantharam, V. 1989*a*. How large delays build up in a GI/G/1 queue. *Queueing Systems: Theory and Applications* 5:345–68.

___. 1989*b*. Metastability and phase transitions associated to dynamic routing in networks. In *Proceedings, 28th IEEE Conference on Decision and Control,* pp. 2549–53. New York: IEEE.

___. *1989c*. The stability region of the finite user slotted aloha protocol. In *Proceedings, 28th IEEE Conference on Decision and Control,* pp. 579–84. New York: IEEE Control Systems Society.

Eastman, L. F. 1989*a*. High frequency optoelectronics. Paper read at meeting, IEEE, Lehigh University section, 15 November 1989, in Lehigh, PA.

___. 1989*b*. Overview of advanced compound semiconductor microwave transistors. Paper read at Gallium Arsenide Device Symposium, 27–30 November 1989, in Pretoria, South Africa.

Farley, D., and *J. Providakes.* 1989. The variation with T_e and T_i of the velocity of unstable ionspheric two-stream waves. *Journal of Geophysical Research* 94:15,415–20.

Hughes, B., and *P. J. Tasker.* 1989. Bias dependence of the MODFET intrinsic model element values at microwave frequencies. *IEEE Transactions on Electron Devices* 36:2267–73.

Kline, R. 1989*a*. Communications: Tesla and the induction motor. *Technology and Culture* 30:1018–23.

___. 1989*b*. Manufacturing a legend: Charles Proteus Steinmetz as modern Jove. *Engineering: Cornell Quarterly* 24(1):49–54.

Kuang, J. B., P. J. Tasker, S. Tatanaphanyarat, W. J. Schaff, L. F. Eastman, G. W. Wang, Y. K. Chen, et al. 1989. Low frequency and microwave characterization of submicron-gate $In_{0.52}Al_{0.48}As/In_{0.53}Ga_{0.47}As/In_{0.52}Al_{0.48}As$ heterojunction metal-semiconductor field-effect transistors. *Journal of Applied Physics* 66:6168–74.

Leeser, M. E. 1989. Reasoning about the function and timing of integrated circuits with interval temporal logic. *IEEE Transactions on Computer-Aided Design* 8(12):1233–46.

Leeser, M., and *G. Brown.* 1989. Verifying high-level hardware synthesis tools. Paper read at 4th International Workshop on High-Level Synthesis, 15–18 October 1989, in Kennebunkport, ME.

Luk, F. T., ed. 1989. *Advanced algorithms and architectures for signal processing. IV.* Bellingham, WA: International Society for Optical Engineering (SPIE).

Nguyen, L. D., P. J. Tasker, D. C. Radulescu, and *L. F. Eastman.* 1989. Characterization of ultra-high-speed pseudomorphic AlGaAs/InGaAs (on GaAs) MODFETs. *IEEE Transactions on Electron Devices* 36:2243–48.

Rey, G. J., C. R. Johnson, Jr., and S. Dasgupta. 1989. On tuning leakage for performance-robust adaptive control. *IEEE Transactions on Automatic Control* 34:1068–71.

Sahr, J. D., D. T. Farley, and *W. E. Swartz.* 1989. Removal of aliasing in pulse-to-pulse Doppler radar measurements. *Radio Science* 24:697–704.

Schneider, I., and *C. R. Pollock.* 1989. Optically induced reorientational aggregation and the stability of F_2^+ color-center lasers. *Optics Letters* 14:1315–17.

Sethares, W. A., B. D. O. Anderson, and *C. R. Johnson, Jr.* 1989. Adaptive algorithms with filtered regressor and filtered error. *Mathematics of Control, Signals, and Systems* 2(4):381–403.

Won, Y. H., K. Yamasaki, T. Daniels-Race, P. J. Tasker, W. J. Schaff, and *L. F. Eastman.* 1989. Improved performance by an optimized planar doped barrier launcher in a GaAs vertical FET. *Electronic Letters* 25:1413–14.

York, R. A., and *R. C. Compton.* 1989. New methods in the practice of microwave engineering education. In *Proceedings, IEEE Frontiers in Education Conference,* pp. 164–66. New York: IEEE Computer Society Press.

Zhu, J. G., S. McKernan, C. B. Carter, W. J. Schaff, and *L. F. Eastman.* 1989. Dislocations in GaAs/Si interfaces. In *Advances in materials, processing, and devices in III–V compound semiconductors,* ed. D. K. Sadana, *L. F. Eastman,* and R. Dupuis, pp. 285–90. Materials Research Society Syposium Proceedings, vol. 144. Pittsburgh, PA: MRS.

■ GEOLOGICAL SCIENCES

Allmendinger, R. W., and *T. E. Jordan.* 1989. Geologic map of the Newfoundland Mountains, northwestern Utah. Map MF-2087. Denver, CO: U.S. Geological Survey.

Beghoul, N., and *M. Barazangi.* 1989. Azimuthal anisotrophy of Pn velocity in the mantle lid beneath the Basin and Range Province, western North America. *EOS, Transactions of the American Geophysical Union* 70(43):1211.

Bloyet, J., *N. Beghoul,* Y. Richard, and C. Froidevaux. 1989. In situ test of a Borehole Extensometer. *Rock Mechanics and Rock Engineering* 22:289–97.

Blythe, A. E., and *J. M. Bird.* 1989. Reactivated Late Mississippian–Early Pennsylvanian Aulocogen in the western and central Brooks range. *EOS, Transactions of the American Geophysical Union* 70(43):1338.

Emerman, S. H., and *R. Marrett.* 1989. Why dikes? *Geology* 18:231–33.

Hearn, T., N. Beghoul, and *M. Barazangi.* 1989. Tomography of the western U.S. from regional arrival times. *EOS, Transactions of the American Geophysical Union* 70(43):1220.

Jordan, T. E., R. W. Allmendinger, and M. D. Crittenden, Jr. (1988.) Geologic map of the Howell quadrangle, Box Elder County, Utah. Map 107. Salt Lake City, UT: Utah Geological and Mineral Survey.

Jordan, T. E., M. D. Crittenden, *R. W. Allmendinger,* and D. M. Miller. (1988.) Geologic map of the Thatcher Mountain quadrangle, Box Elder County, Utah. Salt Lake City, UT: Utah Geological and Mineral Survey.

Jordan, T. E., P. Zeitler, *V. Ramos,* and A. J. W. Gleadow. 1989. Thermochronometric data on the development of the basement peneplain in the Sierras Pampeanas, Argentina. *Journal of South American Earth Sciences* 2:207–22.

Oliver, J. E. 1989. COCORP and fluids in the crust. In *The role of fluids of crustal processes.* Washington, DC: National Academy Press.

■ MATERIALS SCIENCE AND ENGINEERING

Agrawal, D. C., R. Raj, and *C. Cohen.* 1989. Nucleation of flocs in dilute colloidal suspensions. *Journal of the American Ceramics Society* 72(11):2148–53.

Børgesen, P., and *D. A. Lilienfeld.* 1989. On the mixing of Cu and Y by Xe ions. *Journal of Applied Physics* 66:3298–303.

Børgesen, P., D. A. Lilienfeld, and *H. H. Johnson.* 1989. The Au-Ag ion mixing rate—disagreement with theory resolved. *Applied Physics Letters* 55:2497–99.

Crist, B., *P. F. Green, R. A. L. Jones,* and *E. J. Kramer.* 1989. Self-diffusion of hydrogenated polybutadiene by forward recoil spectroscopy. *Macromolecules* 22:2857–58.

Custer, J. S., M. O. Thompson, and J. M. Poate. 1989. Segregation of Ag and Cu during ion beam and thermally induced recrystallization of amorphous Si. In *Processing and characterization of materials using ion beams,* ed. L. E. Rehn, J. Greene, and F. A. Smidt, pp. 545–50. Materials Research Society Symposium Proceedings, vol. 128. Pittsburgh, PA: MRS.

Franke, P., and R. Dieckmann. 1989. Nonstoichiometry and tracer diffusion in mixed iron manganese spinels. Paper read at The Minerals, Metals, and Materials (TIMS) Society Fall Meeting, 1–5 October 1989, in Indianapolis, IN.

Kennefick, C. M., and *R. Raj.* 1989. Copper on sapphire: Stability of thin films at 0.7 Tm. *Acta Metallugica* 37(11):2947–52.

Noh, T. W., A. J. Sievers, L. A. Xue, and *R. Raj.* 1989. Investigation of the infrared properties of ZnS diamond composites. *Optics Letters* 14(22):1260–62.

Palmstrøm, C. J., S. Mounier, T. G. Finstad, N. Tabatabie, S. J. Allen, T. Sands, T. Cheeks, P. F. Miceli, and *J. G. Zhu.* 1989. Characterization of ErAs/GaAs and GaAs/ErAs/GaAs structures. *Materials Research Society Symposium Proceedings,* vol. 160, pp. 325–30. Pittsburgh, PA: MRS.

Panda, P., W. M. Mobley, and *R. Raj.* 1989. Effect of the heating rate on the relative rates of sintering and crystallization in glass. *Journal of the American Ceramics Society* 72(12):2361–64.

Pinnavaria, T. J., M. Rameswaran, E. D. Dimotakis, *E. P. Giannelis,* and E. G. Rightor. 1989. Carbon monoxide hydrogenation selectivity of catalysts derived from ruthenium clusters on acidic pillared clay supports. *Faraday Discussions of the Chemical Society* 87:227.

Polman, A., W. C. Sinke, *M. J. Uttormark,* and *M. O. Thompson.* 1989. Pulsed-laser induced transient phase transformations at the Si-H_2O interface. *Journal of Materials Research* 4:843–56.

Schuster, D., *R. Dieckmann,* W. Schilling, and W. Schweika. 1989. Neutron scattering study of the equilibrium structure in understoichiometric MnO. Paper read at 1989 Fall Meeting, Materials Research Society, 27 November–2 December 1989, in Boston, MA.

Schuster, D., W. Schweika, and *R. Dieckmann.* 1989. The question of vacancy clusters in manganosite $Mn_{1-A}O$. *Berichte Bunsengesellschaft für Physikalische Chemie* 93(11):1347–49.

Tead, S. F., E. J. Kramer, T. P. Russell, and W. Volksen. 1989. Solvent and curing effects on diffusion at polyimide interfaces. In *Interfaces between polymers, metals, and ceramics,* ed. B. M. DeKoven, A. J. Gellman, and R. Rosenberg, pp. 239–48. Materials Research Society Symposium Proceedings, vol. 153. Pittsburgh, PA: MRS.

Vanderborgh, C. A., Y. K. Vohra, and *A. L. Ruoff.* 1989. Structural phase transitions in InSb to 66 GPa. *Physical Review B* 40:12450–56.

Xue, L. A., and *R. Raj.* 1989. Superplastic deformation of zinc sulfide near its transformation temperature (1020° C). *Journal of the American Ceramics Society* 72(10):1792–96.

Zhu, J. G., C. J. Palmstrøm, K. C. Garrisson, and *C. B. Carter.* 1989. Phase boundaries between GaAs and other cubic materials. In *Proceedings, EMAG '89,* pp. 411–14. Institute of Physics Conference Series, vol. 98, New York: IOP.

Zhu, J. G., C. J. Palmstrøm, S. Mounier, and *C. B. Carter.* 1989. Microstructure of the epitactically grown GaAs/ErAs/GaAs. *Applied Physics Letters* 56(14):1323–25.

■ MECHANICAL AND AEROSPACE ENGINEERING

Boedo, S., and *J. F. Booker.* 1989. Transient dynamics of engine bearing systems. In *Tribological design of machine elements,* ed. D. Dowson, C. M. Taylor, M. M. Godet, and D. Berthe, pp. 323–32. Amsterdam, The Netherlands: Elsevier.

Booker, J. F. 1989. Basic equations for fluid films with variable properties. *Journal of Tribology* 111:475–83.

Chinchalkar, S., and *D. L. Taylor.* 1989. Loading and material property uncertainties in finite element analyses for orthopaedics. Paper read at Army Research Office 35th Conference on the Design of Experiments in Army Research, Development, and Testing, 18–20 October 1989, in Monterey, CA.

Edidin, A., and *D. L. Taylor.* 1989. Calibration of the image segmentation threshold value using geometric phantoms. Paper read at Hospital of the University of Pennsylvania 3-D Imaging in Medicine Conference, 15–19 November 1989, in San Diego, CA.

Kumar, A., J. F. Booker, and P. K. Goenka. 1989. Dynamically loaded journal bearing: A modal approach to the EHL design analysis. In *Tribological design of machine elements,* ed. D. Dowson, C. M. Taylor, M. M. Godet, and D. Berthe, pp. 305–15, 508–10. Amsterdam, The Netherlands: Elsevier.

Robillard, L., and *K. E. Torrance.* 1989. Convective heat transfer in an annular porous layer rotating about a horizontal axis. Paper read at 9th Miami International Congress on Energy and Environment, 11–13 December 1989, in Miami Beach, FL.

Trentacosta, J. D., *D. L. Bartel,* and D. A. O'Neil. 1989. Advanced composite fracture fixation plates. Paper read at Winter Annual Meeting, American Society of Mechanical Engineers, 10–15 December 1989, in San Francisco, CA.

Veeravalli, S., and *Z. Warhaft*. 1989. The shearless turbulence mixing layer. *Journal of Fluid Mechanics* 207:191–229.

Wang, K. K. 1989. The basic research issues in computer-aided design and manufacturing processes. In *Organization of engineering knowledge for product modelling in computer integrated manufacturing*, ed. T. Sata, pp. 39–59. Amsterdam: Elsevier Science.

■ OPERATIONS RESEARCH AND INDUSTRIAL ENGINEERING

Carvalho, P. C. P., and *L. E. Trotter, Jr.* 1989. An abstract linear duality model. *Mathematics of Operations Research* 14(4):639–63.

Davis, R., and *S. Resnick*. 1989. Basic properties and prediction of max-arma processes. *Advances in Applied Probabilities* 21:781–803.

Giltinan, D. M., and *D. Ruppert*. 1989. Fitting heteroscedastic regression models to individual pharmacokinetic data using standard statistical software. *Journal of Pharmacokinetics and Biopharmaceutics* 17:601–14.

Goldfarb, D., and *M. J. Todd*. 1989. Linear programming. In *Optimization*, ed. G. L. Nemhauser, A. H. G. Rinnooy Kan, and *M. J. Todd*, pp. 73–170. Handbooks in Operations Research and Management Science, vol. 1. Amsterdam: North-Holland.

Jennison, C., and *B. W. Turnbull*. 1989. Interim analyses: The repeated confidence interval approach. *Journal of the Royal Statistical Society B* 51:305–61.

Llewellyn, D. C., and *L. E. Trotter, Jr.* 1989. On abstract integral dependence. *Mathematics of Operations Research* 14(4):626–38.

Prabhu, N. U., ed. 1989. *Mathematical theory of queueing systems*. Basel, Switzerland: J. C. Baltzer.

Prabhu, N. U., and Y. Zhu. 1989. Markov-modulated queueing systems. *Queueing Systems Theory and Applications* 5:215–45.

Resnick, S., and E. Willekens. 1989. Quantifying closeness of distributions of sums and maxima when tails are fat. *Stochastic Processes and Their Applications* 33:201–16.

Tardos, É. 1989. *Improved approximation algorithm for concurrent multi-commodity flows*. School of Operations Research and Industrial Engineering report no. 872. Ithaca, NY: Cornell University.

Todd, M. J. 1989*a*. On the convergence of algorithms for unconstrained minimization. *IMA Journal of Numerical Analysis* 9:435–41.

___. 1989*b*. Recent developments and new directions in linear programming. In *Mathematical programming: Recent developments and applications*, ed. M. Iri and K. Tanabe, pp. 109–57. Dordrecht, The Netherlands: Kluwer.

■ THEORETICAL AND APPLIED MECHANICS

Black, R. D., H. D. Conway, and *C.-Y. Li*. 1989. Simulation of thermal stress cycles in thin, continuous aluminum alloy films deposited on oxidized silicon substrates. Paper read at American Society of Mechanical Engineering Winter Annual Meeting, 10–15 December 1989, in San Francisco, CA.

Burns, J. A., and *R. A. Kolvoord*. 1989. Periodicities in rings: Keeler gap and Saturn's F ring—or—Give us enough variables and we can match most data. Paper read at Division for Planetary Sciences 21st Meeting, 31 October–3 November 1989, in Providence, RI.

Burns, J. A., R. A. Kolvoord, and *D. P. Hamilton*. 1989. An assessment of potential hazards to the Cassini spacecraft from debris along satellite orbits. In *Cassini mission: Proposal information package*, vol. 13 *(Physical models)*, pp. 6.1–6.23. (Technical report JPL PD 699–11.) Pasadena, CA: Jet Propulsion Laboratory.

Chen, Y.-C, and K. Raj Rajagopal. 1989. Stability of deformation of an elastic layer. *Archive for Rational Mechanics and Analysis* 108(1):1–9.

Golnaraghi, M. F., F. C. Moon, and *R. H. Rand*. 1989. Resonance in a high-speed flexible-arm robot. *Journal of Dynamics and Stability of Systems* 4:169–88.

Henstenburg, R. B., and *S. L. Phoenix*. 1989. Interfacial shear strength studies using the single-filament-composite test. II: A probability model and Monte Carlo simulation. *Polymer Composites* 10(6):389–408.

Kolvoord, R. A., and *J. A. Burns*. 1989. Numerical simulations of narrow planetary rings: An animation. *Celestial Mechanics* 45:321–22.

Netravali, A. N., P. Schwartz, and *S. L. Phoenix*. 1989. Study of interfaces of high-performance glass fibers and DGEBA-based epoxy resins using single-fiber-composite test. *Polymer Composites* 10(6):385–88.

Rand, R. 1989. Perturbation methods and computer algebra. In *Symbolic computation: Application to scientific computing*, ed. R. Grossman, pp. 139–51. Philadelphia, PA: Society for Industrial and Applied Mathematics (SIAM).

Sachse, W. 1989. Quantitative ultrasonic measurements in composite materials. Paper read at 14th Annual Mechanics of Composites Review, 31 October–1 November 1989, in Dayton, OH.

Sykes, M. V., R. J. Greenberg, *S. F. Dermott, P. D. Nicholson, J. A. Burns*, and T. N. Gautier. 1989. Dust bands in the asteroid belt. In *Asteroids II*, ed. R. Binzel, T. Gehrels, and M. S. Matthews, pp. 336–67. Tucson, AZ: University of Arizona Press.

ENGINEERING
Cornell Quarterly

Published by the College of Engineering
Cornell University

Editor: Gladys McConkey

Associate Editor and Illustrator: David Price

Editorial Assistant: Lindy Costello

Circulation Manager: Janet Brown-Aist

Printing: Davis Press
Worcester, Massachusetts

Photography credits:
Don Albern: 29 (bottom)
Charles Harrington: outside front cover (top row middle, bottom row middle), 1 (second from top), 2, 3, 5, 7 (top), 16 (three on right), 17, 23, 29 (top)
Doug Hicks: 14, 16 (left), 21
Chris Hildreth: 18
David Lynch-Benjamin: 1 (third from top), 11, 25
Gladys McConkey: 10 (top)
Tim Moersh: 24
John Pachai: 1 (bottom), 31
Jon Reis: 7 (bottom), 33 (bottom), 34 (right)
David Ruether: cover 1 (top row right, bottom row left), 1 (top), 4, 6 (top), 9, 10 (bottom), 27 (right), 32, 33 (top), 34 (left), 36
C. Hadley Smith: 27 (bottom left)
Clayton Smith: 27 (top)

Second prize in this spring's photo-essay contest was won by Diana Marsh; this photograph is among those in her winning group. The contest, open to Cornell engineering undergraduates, was sponsored by the Engineering Ambassadors Association and the Eastman Kodak Company (see the inside front cover).

ENGINEERING
Cornell Quarterly
(ISSN 0013-7871)
Carpenter Hall, Ithaca, N.Y. 14853

Second Class
Postage Paid at
Ithaca, N.Y. 14850
and additional offices