Newsjournal of the Society for Industrial and Applied Mathematics

siam news

Volume 30 / Number 8
October 1997

SIAM Elections: Get to Know the Candidates

As this issue of *SIAM News* began to take shape, Barry Cipra's article on recent work of Mary Wheeler and her colleagues at the University of Texas, Austin, emerged as an especially timely contribution—beyond the fact that Wheeler is working on mathematical models of bioremediation efforts at some of the country's most notorious waste sites, she is one of the two candidates for president of SIAM. Cipra's article (page 24) gives readers a glimpse of the group's current models, notable for their inclusion of the geochemistry of the environment and their introduction of multiphase terms. The prediction by one such model of an unusual mode of propagation for the radioisotope strontium-90, says Wheeler, could not have been done "by a geochemistry or a transport code alone."

Lest *SIAM News* appear to be taking a stand, readers are referred to an earlier issue of *SIAM News*, for which, as it happens, Gilbert Strang of MIT, Wheeler's opponent in the upcoming election, took the time to acquaint readers of *SIAM News* with one of his current interests ("The Mathematics of GPS," June 1997, page 1; http://www.siam.org/siamnews). In the clear, informal style that SIAM members have come to appreciate in his talks, expository papers, and textbooks, Strang describes the weighted least squares problem involved in the basic measurements of distance between the receivers and satellites of a global positioning system.

Both Wheeler and Strang have intense records of involvement in SIAM activities. Strang, who recently stepped down after three terms as vice president for education, is responsible for such successful innovations as the SIAM Student Conference, held for the first time at Clemson University in March of 1996 and on its way to becoming a SIAM tradition. Wheeler, a three-term member of the board of trustees, is a co-founder, one-time chair, and the current vice-chair of the SIAM Activity Group on Geosciences.

It's clear that SIAM is continuing its tradition of outstanding candidates for the presidency. A vice president at large, a secretary, three board members, and four council members will also be elected. All SIAM members should receive ballots in the mail some time in October; they must be returned to SIAM in November. Be sure to cast your votes!

"The solution of significant scientific and economic problems in today's world requires integrated multidisciplinary research teams with strong backgrounds in applied mathematics and computational science," says Mary Wheeler. "SIAM is well positioned to facilitate and to provide leadership in encouraging closer cooperation among industry and business, universities, and government laboratories, both nationally and internationally."

Gilbert Strang (right), shown here with Tom Kailath and Donald Knuth at the "networking" picnic lunch held during SIAM's 45th Anniversary Meeting. "I would like to see SIAM grow in its influence on mathematics," Strang says. "We represent the parts of mathematics that contribute most to society as a whole. Membership outside the U.S. is growing properly, and so should membership inside—without changing the character and spirit of SIAM. I believe that we can cooperate with other societies, while taking the lead in our relation to students, to industry, and to society."

Does Industry Want Mathematicians? (Does Academia Care?)

By Robert Styer

Does business want or need mathematicians? Experts in the field—John Hamilton (Computational Science Laboratory, Eastman Kodak Company), Aaron Owens (Modeling and Simulation Group, Dupont Central Research and Development Group), Linda Banecker and Thomas Pratt (Technical Operations, Lockheed–Martin Management and Data Systems), and Robert Borrelli (Harvey Mudd College)—presented their perspectives on this question at the second annual Mathematics and its Applications Throughout the Curriculum Workshop at Villanova University in June 1997. In spite of the different backgrounds of the individual speakers, one common thread wound through the discussions: When using the term "industrial mathematician," we must put the emphasis on "industrial," not on "mathematician." This perspective appeared in many guises, hinted at many consequences, and provided some thought-provoking suggestions for academia.

The Value of a Model

The industrial mathematician works toward the goals of industry, not the goals of mathematical elegance or completeness. Nothing illustrates this more clearly than a story that Robert Borrelli shared with workshop participants.

Many years ago, when he was working at Philco Ford, Borrelli explained, the company was working on satellite stabilization problems for the government. The company was using massive computer runs to optimize the stabilization design parameters. On his own initiative, Borrelli found an exact formula for the optimum parameters; his solution would have even saved massive amounts of computer time. However, his boss was not happy with this achievement. Why? Because Philco Ford was receiving large sums of government money for those computer runs; Borrelli had optimized the wrong variable!

Today, Borrelli guides the Mathematics Clinic at Harvey Mudd College—a program that he helped found more than 20 years ago. The clinic supervises teams of senior mathematics majors who consult on industry problems and learn first-hand the nature of industrial mathematics.

Businesses are also reinterpreting traditional academic categories to reflect these industrial goals, reported Dupont's Aaron Owens. When he was hired by Dupont, he explained, the company had four people who held the job title of mathematician. That title no longer exists. Even the names of the groups in which mathematicians work have changed: The former Applied Mathematics Group is now the Modeling and Simulation Group, the Applied Statistics Group has become the Quality Management Group, and the Operations Research Group has acquired the goal-oriented title of Supply Chain Optimization Group. "I don't do problems that interest me," said Owens. "I work on problems important to Dupont."

See **Industry** *on page 8*

SIAM's E-Journals To Banish Backlogs, Speed Publication

Worst-case scenario: A faculty member is denied tenure on the grounds of insufficient publications; a paper describing highly regarded work by the candidate is languishing in the files of a respected journal.

The unfortunate faculty member's paper is part of what's known as a journal backlog—papers that have been accepted for publication but will not appear in print, or even go into production, until all papers accepted before them have gone through the production process; for SIAM's ten research journals, current backlogs range from an issue's worth of papers to a year's worth of papers and are responsible for publication delays of various durations.

In the past, the editorial boards of the SIAM journals were routinely asked to take time out from their main concerns—the quality of the papers published, editorial direction and policy—to brainstorm about the backlog problem. The vice president for publications (currently Linda Petzold of the University of California, Santa Barbara) has communicated regularly with the editors-in-chief and the SIAM office about the problem. It has appeared many times on the agenda of the SIAM Board of Trustees. And in April 1997 an ad hoc committee of volunteers interested and experienced in this area, including Petzold and several editors-in-chief, met with SIAM staff members to discuss the problem in detail and formulate a solution.

At the SIAM 45th Anniversary Meeting at Stanford University this summer, the board approved a carefully designed plan that, building on the existing electronic versions of the journals (SIAM Journals Online), will attack the backlog problem and put in place a new editorial/production process for the journals. For journal authors, the plan will have one highly beneficial result: After an initial catch-up phase, a paper that has been accepted for publication will be copy edited and published electronically within approximately four months of the acceptance date. The electronic version will be the final form of the paper—it can be cited in the literature and included in the author's list of publications. SIAM will continue to maintain the standards it has set for the journal peer review, editorial, and production processes.

Subscribers will benefit from the plan as well—new research results will be disseminated to electronic journal subscribers far earlier than with the traditional system; during the catch-up phase mentioned earlier, the papers that are now part of the print backlog will be published electronically, in their final form, months to years before they would have appeared in print.

Is this the end of print versions of the journals? No, says Linda Petzold, SIAM will continue to produce print versions

See **E-Journals** *on page 3*

siam®
SOCIETY for INDUSTRIAL and APPLIED MATHEMATICS
3600 University City Science Center
Philadelphia, PA 19104-2688

Nonprofit Org.
U.S. Postage
PAID
Permit No. 2609
Phila., PA

Time-Sensitive Material

Industry

continued from page 1

Industrial goals affect the way mathematicians work in several ways. These goals often dominate the mathematical modeling process. "Often, the question is which way to adjust a process," said Owens. "You have a 50–50 chance of getting the answer right! Accurate and elegant models are fine, but what really matters is how rapidly you can answer yes/no, up/down."

"The model does not have to be perfect to be useful," said Kodak's John Hamilton. "The value of a model is measured by the importance of the question it answers." He argued that simple models are more tractable and easier to verify. And while industrial models are not detailed enough to replace experimentation, they should be able to predict efficiently fruitful ranges for experimental parameters.

Industrial goals also affect where mathematics is most useful in industry. For example, Hamilton outlined two distinct goals of business: (1) to reduce product development time and (2) to achieve robust manufacturing processes. Industrial mathematicians can reduce product development times significantly when their models specify more fruitful experimental ranges, he said.

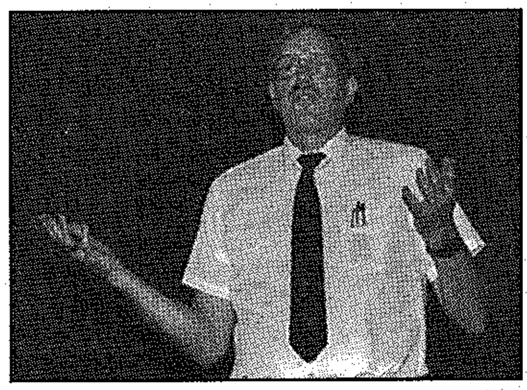
The closer one gets to production, however, the less mathematical models contribute. Manufacturing managers rightly abhor tinkering with tried and true processes, added Hamilton. "An ill-advised change in the process can literally cost millions of dollars in lost production," he explained, "so they are cautious and slow to change."

"Job #1 in production is to maintain production," asserted Owens. "All that counts is throughput." Consequently, mathematical research focuses on rapid product development. In today's business climate, a product needs to be developed quickly; research then switches to a new product line.

Hamilton discussed several areas in which he has worked: medical x-ray intensifying screens, blood serum analysis (fluid flow in a porous medium), stockroom analysis, quantum chemistry and dye design, color interpolation for digital cameras, and phase noise blur filter design. Thomas Pratt of Lockheed–Martin identified mathematical models of the turbine blade loss that results from collisions with birds, blade design, fan blade ordering, and single crystal growth as areas in which he and other mathematicians are interested. As these diverse lists suggest, the industrial mathematician must be flexible and willing to digest plenty of nonmathematical material. According to Owens, mathematical flexibility is critical: Owens earned his degree in theoretical astrophysics, yet he uses tools from numerical modeling, parameter estimation, systems of stiff ODEs, neural networks, partial least squares, and exploratory data analysis. In fact, he claims to have gone through several career changes—all within Dupont.

Part of a Larger Team and A Bigger Picture

Industrial mathematicians do not chart the course of industrial research. Rather, they function as a small but integral part of a larger team, and their mathematical training is but one element in a bigger picture. Owens described the mathematical practitioner as an internal consultant, providing small parts to larger projects. As would any consultant, the industrial mathematician has a vested interest in finding promising project ideas, selling these ideas to the team, and ensuring that the results are used. Thus, communication skills are essential; internal memos and progress reports serve as industry's "publications." Hamilton concurred with Owens, adding, "You need to keep checking to see if you are still working on the right problem (talk, talk, talk!). The problem-solving process is iterative. . . The learning never ends."



The mathematics he uses in his work at the Eastman Kodak Company might be mostly at the undergraduate level, says John Hamilton, but it's "applied with a graduate perspective." Elaborating on his comment from the MATC workshop, Hamilton takes another look at problem solving in industry: "By the time the computations are being done, it just looks like linear (ho-hum) algebra, but by then the problem has already been defined, the level of approximation has already been set, and the alternative methods have already been evaluated. Misjudge the problem there and all the linear algebra in the world won't fix it."

In order to be an effective member of this team, the speakers observed, the industrial mathematician must have good computing skills. According to Owens, spreadsheets, the universal form of communication, are ubiquitous. Almost all statistical functions are computer-based; almost all modeling projects end with a computer model; and almost all mathematics in industry is done on computers. All results come out of a computer even when much of the work is analysis, said Hamilton.

Hamilton reported on his informal survey of 50 recent Kodak hires who had listed a degree in mathematics on their resumes; more than half were hired into jobs that included the word "software" in the job title, and many were hired because of specific software experience.

Linda Banecker corroborated these anecdotal observations. As a hiring manager for Lockheed–Martin, she is acutely aware of the lack of people trained in information technology; this year, her company has hired less than two-thirds of its quota for technical personnel. And, according to Banecker, a conservative estimate of unfilled information technology positions nationwide is 190,000; 68% of IT companies cite the lack of skilled workers as a barrier to future growth. To attract talented recent college graduates, Lockheed–Martin offers an impressive Engineering Leadership Development Program and a Technical Development Curriculum. The training curriculum begins with a hefty dose of mathematics and then quickly moves to a variety of computing and business and engineering topics.

Owens also stressed the dominant role of statistical tools for industrial mathematicians. Observation errors, systematic and random, are always factors in the industrial setting, he explained. The data quality from research is often uneven, and the quality of production process data is even worse. At Dupont, he reported, a large portion of the work is carried out by bachelor's degree technicians, who have a great need for numerical computing and visualization and spreadsheet skills.

Owens pointed to the large amounts of

See **Industry** *on page 10*

Industry

continued from page 8

time wasted by naive researchers analyzing two-point experiments with large error bars. "They run an experiment with the parameter first moved up then down, and make a decision based on these two data points, only to find that a bad product results," he explained. "The simplest observation that there is noise in observations is not getting through to graduates. The statistical education of engineers and scientists is sorely lacking, at least at the institutions from which Dupont hires!"

Reading between the lines, one might conclude that business goals do not correlate to academic mathematical goals, that computer skills and statistical skills are much more important than classical mathematical academic training, and that mathematicians are only a minuscule part of the industrial scene. To add insult to injury, each speaker cited other problem areas: Hamilton said that in most of his work at Kodak, he uses mathematical tools taught at the undergraduate level; Owens reported that three of the four mathematicians working at Dupont on his arrival are now doing computing or experimental work; Borrelli pointed to the difficulty of finding suitable industrial problems for the Mathematics Clinic student teams; and Banecker acknowledged that the mathematics component of the training curriculum acts like a filter to weed out those who would not survive the later portions of the training.

Proof Is in the Hiring

Does mathematical training per se have any value for industry? Each speaker provided some insight into this question: After completing a master's degree in mathematics, Linda Banecker began her industrial career as a programmer, typical of many of Lockheed–Martin's new hires. Programming is actually a way station that allows time for a new employee to adjust to the corporate climate, she said; it often takes a couple of years for a newcomer to learn enough about the company's goals and structure to become productive in a design and development role. Once an employee is working in development, computing skills alone are simply not sufficient. Banecker welcomes applicants who have skills in mathematics: "It is much easier to teach a mathematician to program than to teach a programmer some mathematics."

Lockheed–Martin hiring manager Linda Banecker, like many of the company's new hires, began her industrial career as a programmer. Programming can be a way station that allows a new employee to adjust to the corporate environment, she believes, although she welcomes applicants who have mathematical backgrounds: "It is much easier to teach a mathematician to program than to teach a programmer some mathematics."

Although much of the mathematics used by John Hamilton is at the undergraduate level, it is applied with a graduate perspective. It is this perspective that provides the mathematical flexibility required by industry. Mathematicians are thought to have good analytical skills and can carry out all sorts of computational tasks without getting bogged down in the equations, Hamilton explained; therefore, the PhD mathematician has a genuine edge. "Mathematical maturity is an intangible but critical asset," he added. "It lets you wade into places you might otherwise avoid."

For Robert Borrelli, the absolute proof that industry values mathematicians is that they hire them. Borrelli considers the Mathematics Clinic to be an educational success: The students learn to work in teams, they see the need for constant communication with their clients, and they gain respect for the modeling process. The clinic also benefits industry: Several companies have brought project after project to the clinic. In fact, Borrelli said, companies occasionally make attractive job offers to the entire student team (and sometimes the faculty adviser!).

Always Room for Improvement

So there is value in a mathematical education! The recognition of this fact, however, did not prevent the speakers from offering suggestions for improvement. Linda Banecker stressed the inability of new graduates to apply their skills to real-world problems. She reiterated the recommendations of the Information Technology Association of America: Emphasize more internships and other business-world experiences; hire university instructors with industrial experience; provide such experience to current instructors; and, of course, increase the number of graduating technical majors.

Aaron Owens closed his talk with several deliberately controversial and thought-provoking suggestions to the academic community: All college graduates should study economics, computing, quantitative numerics, and applied statistics; technical graduates should have at least a year in each subject. Faculty members should emphasize applications in all mathematics courses; better still, they should integrate mathematics and computing fully with subject-matter courses. All math/science/engineering courses should include assignments in technical writing and presentations.

Can academia change so dramatically? "Just as production managers are concerned with throughput and hate to tamper with a process that works, why should a university upset its current system and risk losing its throughput?" asked one skeptical workshop participant. Clearly, tension exists between those who advocate the novel educational developments showcased at this MATC workshop and the average professor who is producing in the trenches. Even MATC workshop participants could not agree on all of these points, but everyone did agree that the speakers from industrial mathematics stimulated both thought and discussion.

A further discussion of these and other educational issues is available in the SIAM Report on Mathematics in Industry, *which is posted on the Web at http://www.siam.org.*

Robert Styer is an associate professor in the Department of Mathematical Sciences at Villanova University.

NSF Offers Graduate and Minority Fellowships

The National Science Foundation invites applications for graduate fellowships and minority graduate fellowships in the mathematical sciences for 1998.

For information on eligibility and the application process, including deadlines, contact: NSF Graduate Research Fellowship Program, Oak Ridge Associated Universities, PO Box 3010, Oak Ridge, TN 37831–3010; (423) 241–4300; fax: (423) 241–4513; nsfgrfp@orau.gov; http://www.ehr.nsf.gov/EHR/DGE/grf.htm.

Additional information on federal agency programs can be found at http://www.siam.org/siamnews.htm.