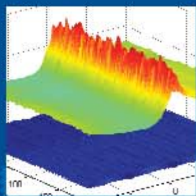
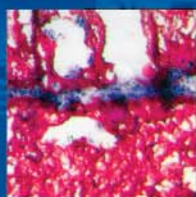
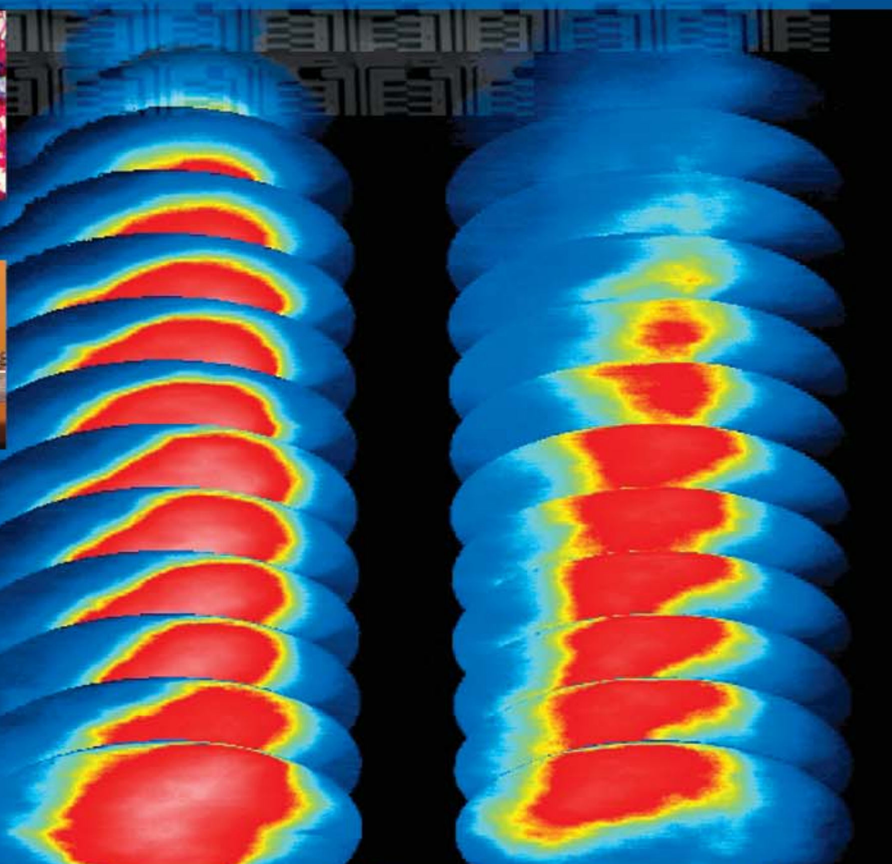
University of Michigan

College of Engineering

03-04







MECHANICAL ENGINEERING ANNUAL REPORT

MichiganEngineering

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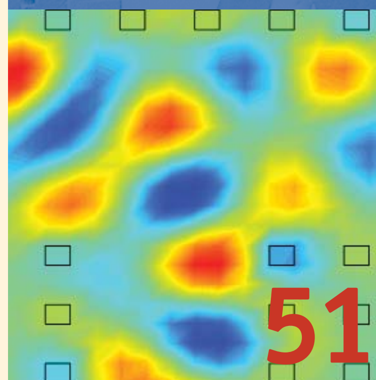


Message from the Chair

I am delighted to summarize the wonderful accomplishments of the ME Department during the academic year 2003-04. Despite the tough economic realities and the reduction in the state support to our University, our ME Department continued to thrive in the past year. We are very proud of the outstanding achievements of our students and alumni, the exceptional performance of our faculty in their teaching, research and service activities, and the commitment of our dedicated staff to our mission.

The ME Department has reaffirmed its dedication to excellence in the classroom and its commitment to continual assessment and improvement of our undergraduate and graduate curricula and instructional delivery methods. Our undergraduate program has been ranked #2, and our graduate program has been ranked #5 in the nation by the *US News and World Report.* As a group, our faculty members have received the highest ever, three year average teaching evaluations for our required core undergraduate courses. In addition, our faculty has invested a great deal of energy in establishing new course offerings that provide our students with opportunities in emerging areas of mechanical engineering. Furthermore, our global education partnerships with Shanghai Jiao Tong University in China and Korea Advanced Institute of Science & Technology in Korea have matured and expanded.

Our research activities have continued to be very strong during academic year 2003-04, with research expenditures reaching an all time high at close to $29 million. According to available data, this places our department at the top relative to our peer institutions in terms of both absolute research volume as well as research volume per full-time equivalent tenure track faculty member. This impressive growth is a result of continued strong partnerships in automotive and manufacturing engineering between academia-government-industry, as well as expansion into new areas, notably bio-systems, energy-systems and micro-nano/systems.

This past summer, the Automotive Research Center (ARC), established in 1994, received a $40 million, five-year research contract funded by the Department of Defense, the largest single research contract in the history of the College of Engineering. The continuing success and growth of the ARC validates the importance of establishing such a collaborative environment to address multidisciplinary and dual-use research issues. Concerns with rising energy costs, scarce resources and efficient design processes are shared by the military and commercial manufacturers. The breadth of its current research and its established collaborations make the ARC uniquely positioned to address the research challenges associated with improving mobility and providing clean and affordable power for the future.

Our world renown design and manufacturing centers, including the NSF Engineering Research Center on Reconfigurable Manufacturing Systems, the S.M. Wu

message from the chair

Manufacturing Research Center and the GM Collaborative Research Laboratory in Advanced Vehicle Manufacturing, have continued to perform ground breaking research that spans all scales, from macro to meso and micro. Our department is also home to three NSF Industry/University Cooperative Research Centers in Dimensional Measurement and Control in Manufacturing, Intelligent Maintenance Systems and Precision Forming. In all these activities, our researchers are exploring how to design and manufacture products with higher quality and flexibility, increased responsiveness to market pressures, and in ways that are environmentally responsible and sustainable.

In the emerging areas of bio, micro and nano-systems, ME researchers are investigating an impressive range of research topics that are aimed to improving quality of human life, especially for those suffering due to genetic defects, malfunctioning human organs, age or injuries. Examples of our accomplishments are a new device to detect dysphagia, an innovative approach to prevent and treat childbirth related injuries of first time mothers, and an electrokinetic pump to help patients suffering from hear loss. Our researchers also utilize nano and micro-fabrication techniques to develop molecular sorter prototypes and micro-fluidic pumps, as well as to engineer tendon and bone tissue.

During 2003-04, we have added to our ranks a new faculty member, Kevin Pipe, with research interests in micro and nanoscale thermal physics. In addition, four more faculty members have been granted joint appointments with Mechanical Engineering. Among our outstanding faculty, we are honored to have Professor Yoram Koren who has been elected to the National Academy of Engineering (NAE) for his lifetime contributions to the science, education and practice of manufacturing. We are also delighted with Professor Noboru Kikuchi's inauguration as the Roger L. McCarthy Professor of Mechanical Engineering in recognition of his significant contributions to the field of computational mechanics. We are especially grateful to our benefactor and distinguished ME alumnus Roger McCarthy who was also elected to NAE for his contributions to improving vehicle safety and the reliability of mechanical systems.

Upon reflecting on last year's numerous accomplishments, I want to congratulate and thank all of you — students, alumni, faculty and staff — who have contributed to making the endeavors of our ME Department truly successful. I have no doubt that this coming year, and our future, will be very bright indeed.

Dennis N. Assanis
Professor and Chair, Mechanical Engineering
Jon R. and Beverly S. Holt Professor of Engineering

"This very strong program has well-defined objectives for its teaching and research programs. It is well organized and its members have thought deeply about their directions….We applaud the department's ability to synergistically move into new areas while coupling to its unique position in Automotive Engineering and think that this positioning sets this department apart in the country."

—CoE External Advisory Committee Report, May 2004

$40 Million in Funding As ARC Enters Phase Three

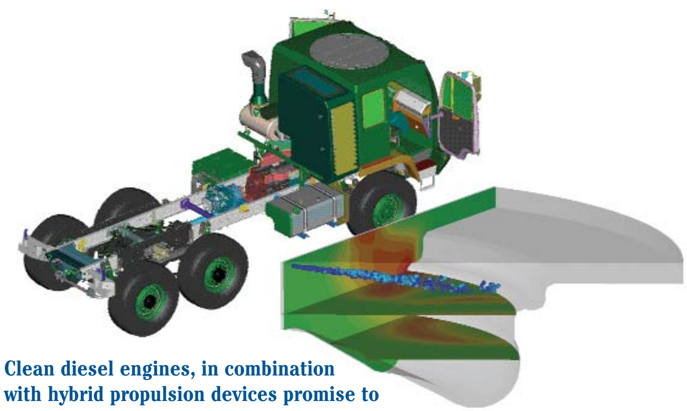
This summer, the Automotive Research Center (ARC) received a $40 million, five-year U.S. Army research contract, the largest single research contract in the history of the College of Engineering. The funding heralds the third phase of the ARC, established in 1994, and some new research imperatives. "The continuing success and growth of the center validates the importance of establishing this kind of collaborative environment to address multidisciplinary and dual-use research issues," said Professor Dennis Assanis, ARC director and ME department chair.

The ARC is a multi-university consortium led by U-M and sponsored by the National Automotive Center at the Research, Development and Engineering Center in Warren, Michigan. It is the most advanced university-based automotive research center in the U.S. The work of the ARC spans a range of topics, and research teams are organized into five thrust areas: dynamics and control of vehicles, led by Professor Jeff Stein; human-centered modeling and simulation, led by Industrial and Operations Engineering Professor Don Chaffin; high-performance structures and materials, led by Professor Christophe Pierre; advanced and hybrid powertrains, led by Wayne State University Professor Naeim Henein; and vehicle system integration, optimization and robustness, led by Professor Greg Hulbert.

Ph.D. student Jonathan Hagena (right) discusses the synergy between engine experimentation and modeling with sponsors and participants of the 2003 SMART (Simulation and Modeling for Acquisition, Requirements and Training) Conference.

Just as in a real car, in vehicle system simulation, the product is as strong as its weakest link. A superb engine that is not seamlessly integrated with an equally superb body and chassis, and with sophisticated controls will not result in a vehicle that is reliable and fun to drive.

"In the ARC, we have been fortunate that every member of the team has risen to the occasion and is eager to collaborate to tackle grand challenge problems at the interface of disciplines. Our agenda is truly a vehicle systems engineering exercise that cannot be addressed without everybody's contribution," Assanis said.



Clean diesel engines, in combination with hybrid propulsion devices promise to significantly reduce fuel consumption and emissions of future military and commercial trucks. ARC pioneering simulation study facilitated partnership between the sponsor and PermoDrive leading to a successful demonstration of the hydraulic hybrid propulsion system.

The ARC has played an invaluable role in the College of Engineering over the past ten years. The Center has truly provided a pillar upon which to build the renaissance of the automotive research activities at U-M and propel it to its current leadership position in automotive engineering.

"We are in the heartland of the automotive world, and it is incumbent upon us to be the leaders and best in automotive research and development," said Assanis. "We are developing cutting-edge methodologies that will enhance the competitiveness of our automotive industry and strength of our military."

Several critical advances have been made, including development of significant new modeling capabilities together with methodologies for integrating and optimizing large-scale systems to effectively model a vehicle as a system. In addition, more than 300 papers have been published based on ARC research, and hundreds of graduate students have worked in the center. The ARC is also recognized for its annual conference, which attracts internationally-renowned participants from industry, academia and government.

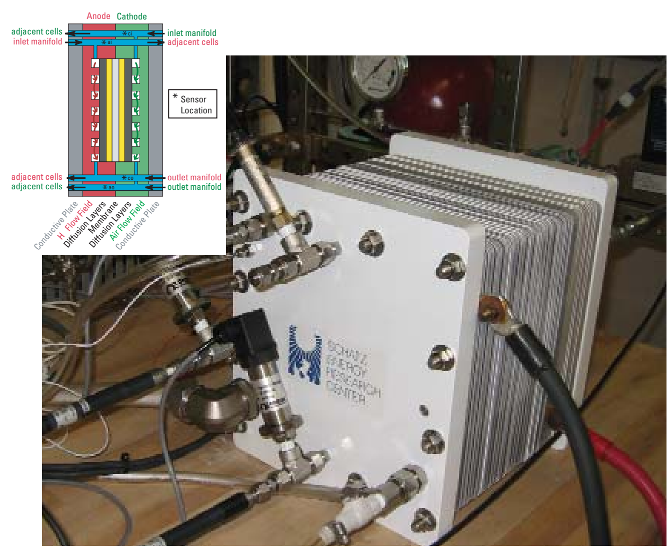
The third phase of the ARC will address research initiatives based on new challenges. Concerns with rising energy costs, scarce

University researchers and industry and government partners gather to celebrate the 10th anniversary of the ARC. From left to right: Zoran Filipi, Panos Papalambros, Jeffrey Stein, Walter Bryzik, Don Chaffin, Dennis Assanis, Greg Hulbert, Naeim Henein, Greg Ohl, Jim Macbain.

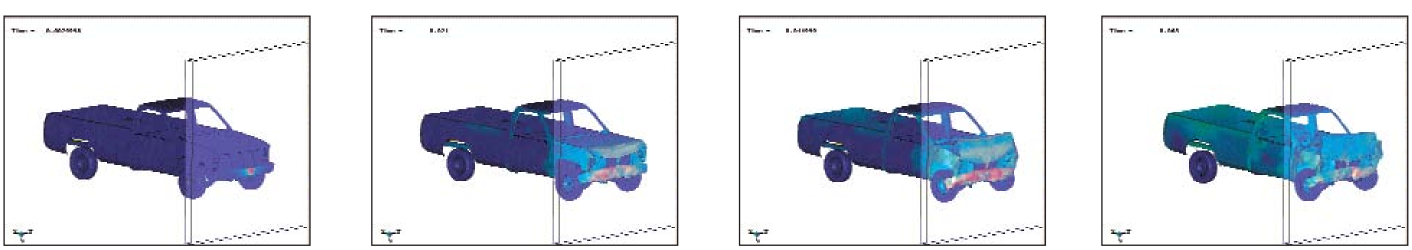
Human simulation, such as modeling the effort required to replace heavy duty truck batteries, allows manufacturers to evaluate the maintenance requirements of future vehicles and propose re-designs of current vehicles.

resources and efficient design processes are shared by the military and commercial manufacturers. The breadth of the current research in the ARC and the already established collaborative links make the center uniquely positioned to address complex research issues related to energy options for the future. Extensive research is being performed into the building blocks of the different hybrid propulsion options, such as advanced clean diesel engines, alternative fuels including hydrogen, as well as fuel cells and fuel processors. Different propulsion options will affect vehicle design, which in turn affects an increasingly diverse cadre of human operators.

"There's a chain reaction that requires research across a range of disciplines and underscores the importance of the dual-use/dual-need concept," says Assanis. "That's what makes the ARC attractive to our industry partners, too. We constantly incorporate new ideas and people. We're reinventing ourselves in an evolutionary way."



Hydrogen fuel cells are being considered as both a future propulsion option, and as auxiliary power units, allowing electrification of diesel engines, and providing power for vehicle electrical systems during engine-off operation.



Crash safety can be significantly improved by well-designed structures. Full-body crash simulations are conducted to optimize the distribution of crush energy by managing crash location and sequence (front to rear).

Industry Collaboration with GM Fosters Innovation

Graduate students Ron Grover (left) and Tim Jacobs discuss advanced injection strategies for premixed diesel combustion, developed through a combination of modeling and experimental work.

Of the nine Collaborative Research Laboratories that General Motors (GM) has established with university partners around the globe, two are based in the ME department. Both the GMCRL in Advanced Vehicle Manufacturing and the GMCRL in Engine Systems Research have been continuing their research projects in areas of strategic importance to the automaker and of intellectual interest to the College of Engineering and the ME faculty.

The collaborative labs "bring together top-notch minds from GM and U-M," said Professor Dennis Assanis, co-director of CRL-ESR. The labs have just completed the second of their five-year partnerships, and that longer-term commitment is invaluable, said Assanis. "That really plays a major role in fostering innovation. You can think outside the box. You can look at applications and take approaches not routinely used in assessing these issues."

That spirit of innovation is evident in the work that's been done over the past year in both labs. In the CRL-AVM, a new technology is about to be tested in production at GM's Lansing Grand River Assembly Plant. Use of the new GM C-Flex robotic part fixturing system allows adaptive control of assembly quality. Modeling results have been attained, according to Professor S. Jack Hu, co-director of CRL-AVM, and now the control models will be implemented on a manual basis at the plant. "Based on the modeling and simulations, we expect to see further improvement in quality," he said.

Work has begun on a manufacturing systems project that uses fictitious play to simulate and optimize manufacturing system design. The work focuses on developing an integrated model of plant investment, production scheduling, and maintenance and optimization techniques. Industrial Operations Engineering Professor Robert Smith leads the project, which "speaks to the interdisciplinary nature of the work we do here," said Hu.

A patent was awarded this year for an "on-line monitoring system and method for short circuit gas metal arc welding processes." Short circuit gas metal arc welding is used for welding hydroformed tubes, which increase vehicle stiffness and reduce weight. Researchers are now applying their welding monitoring knowledge to aluminum joining, which GM has been increasingly using in its body structures and substructures due to the material's lighter weight and increased vehicle fuel efficiency.

In the CRL-ESR, work is under way addressing critical issues on the path towards more efficient, extremely low-emission engine technologies. Four advanced innovative concepts are being considered: the new generation spray-guided direct injection SI engine; gasoline homogeneous charge compression ignition (HCCI) engine; non-standard modes of combustion in a high-speed diesel engine; and aftertreatment devices for clean diesels.

The advanced laser-based imaging techniques are used to identify the causes of potential ignition instabilities in a direct-injection spark-ignition engine. The work will help improve drivability and reduce pollutant formation. Researchers are using multi-pulse laser-induced fluorescence to visualize the fuel distribution and extent of the flames inside an engine. The gas motion is then measured using particle image velocimetry. A recent study characterized the formation of nitric oxide and allowed a better understanding of ways for reducing it. Synergistic modeling work improves predictive capabilities of fuel injector and spray computational models for direct-injection engines. Integrating the physically-based, accurate sub-models and using optimization techniques to match measurements acquired via optical diagnostics validates the simulation tools, thus enabling subsequent explorations of innovative concepts prior to prototype builds.

In parallel with addressing research questions using existing instrumentation, the lab has developed a new optical engine facility for innovative imaging concepts using tracer molecules. "The work will result in improved techniques to measure currently inaccessible processes in engines," said Associate Professor Volker Sick, leader of the laser-diagnostics area. The ongoing investigations of mixing effects of fuels and fluorescence tracers will allow visualization of several fuel components.

The gasoline HCCI engine holds a promise of achieving diesel-like efficiency with practically no emission of nitric oxides (NOx) or particulate matter (PM). Autoignition and combustion rates in HCCI engines are very closely coupled to the thermal boundary conditions. Research using fast-response thermocouples in a single-cylinder gasoline engine has revealed unique characteristics of the heat transfer process in the HCCI engine and enabled derivation of the new heat transfer correlation. In addition, experimental investigations led to a discovery of an innovative way of reducing HCCI burn rates

students' impressions

"In my position as a summer intern at GM R&D, I worked with people from different divisions of GM, and also those from outside GM, and I feel very comfortable that our work conducted in GMCRL does meet the needs of industry. My biggest impression about working in industry is the importance of communication and teamwork. Graduate students in universities usually do research rather independently, while in industry people share knowledge and expertise for the benefit of a whole project. I realized that there is lots of knowledge to learn besides that from the books."

Guosong Lin, GMCRL-AVM

"During the past year, I've had an opportunity to work with one of the GM Assembly plants. Through working with the staff at GM, I've gained a true understanding of the significance of my research. I have found the opportunity to apply my theoretical findings to solve practical manufacturing problems both challenging and rewarding. The other aspect of working in the GMCRL that I enjoy is the opportunity to work with the latest technologies and exchange ideas with the most knowledgeable people in this field."

April Bryan, GMCRL-AVM

"My experience at GM has given me some exposure as to how research and development plays in the corporate environment and will influence what career path I choose when I finish my PhD. My experience in Germany [at the Physical Chemistry Institute, University of Heidelberg] offered the chance to see how approaches to research compare to those here. I also had the chance to meet people of a different culture and to learn German."

Vinod Natarajan, GMCRL-ESR

"My involvement with the GMCRL has tremendously cultivated my professional development. This experience has significantly molded my critical thinking, communication, and teamwork skills through summer internships, joint publications, and conference presentations. Furthermore, the GMRCL has allowed me to understand the immediate implications of my research on streamlining the design process and enhancing product quality."

Ronald Grover, GMCRL-ESR

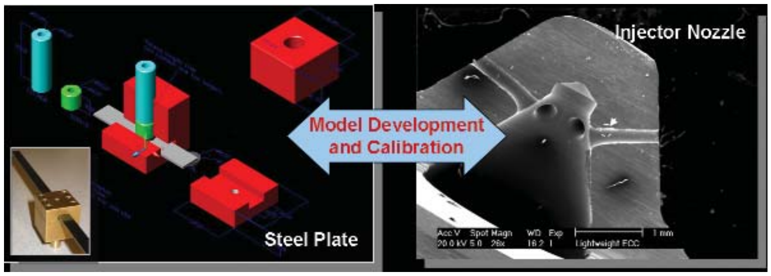
and avoiding knock via charge thermal conditioning. "This invention expands the upper load limit of the HCCI operation," said Associate Research Scientist Zoran Filipi, thrust area leader, "and demonstrates the power of collaboration, combining contributions of UM and GM researchers."

While most researchers are encouraged to think "outside the box," the Clean Diesel Technology team is encouraged to think "inside the box" — the emissions certification box that is. Diesel engines face immense challenges in meeting regulations that will shrink the size of the allowed nitric oxides-PM "box" down to a near-invisible speck by 2010. Responding to the challenge, the diesel engine team develops advanced injection strategies and novel combustion modes for minimizing engine-out emissions. Comprised of both the single- and multi-cylinder engine setups the team has already demonstrated simultaneous reduction of NOx and PM. However, the ultimate success of in-vehicle applications will likely require aftertreatment of the exhaust, and another team is developing sampling methods for speciating the hydrocarbons in diesel engine exhaust. This information is critical for catalyst manufacturers working towards producing more efficient regenerative converters.

Graduate students Eduardo Izquierdo, April Bryan, Jianpeng Yue, Chino Imediegwu compare results of variation simulation models with actual measurements in order to determine the areas of highest variation of an aluminum engine cradle.

DUAL USE SCIENCE AND TECHNOLOGY PROGRAMS WRAP UP

Two Dual Use Science and Technology (DUST) programs came to completion this year, and their results are setting the direction for future research. In an innovative collaboration among the Department of Defense, the University of Michigan and Ford Motor Company and General Motors Corporation respectively, the Mechanical Engineering department has led the charge to further research of benefit to both the military and the automotive industry.



Experiments with a drilled and finished steel plate (left) were used to develop the process model for the Abrasive Flow Machining (AFM), while the actual injector hole geometry was measured before and after the AFM for validation (right).

Over the past three years, the Ford-DUST program, "Simulation Based Design and Demonstration of Next-Generation, Near-Zero Emission Diesel Technology," has met its objective, and then some, of developing a simulation-based engine design environment to help design more environmentally friendly diesel engines. Ultimately, the goal is to achieve maximum fuel economy while minimizing harmful exhaust emissions, explained Professor Dennis Assanis, program director and ME department chair.

In continuation of this work, Ford-DUST has added both in-cylinder engine combustion issues as well as exhaust after-treatment systems that will be critical to meeting the Environmental Protection Agency's new emissions guidelines for 2007/2010. "We've built a sophisticated test cell facility to validate the high fidelity models of engine combustion and emissions processes," said Assanis.

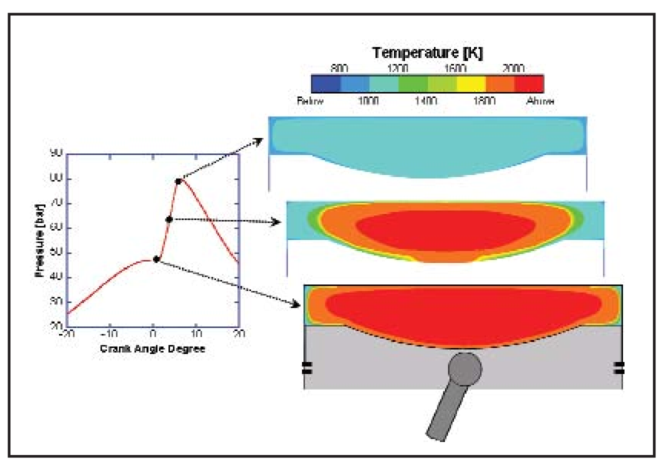
For the past four years the GM-DUST program, "Simulation Based Design and Manufacturing of Next Generation Powertrains," has examined the relationship between manufacturing quality and advanced engine performance. Using simulation models of manufacturing processes and engine and powertrain operations, researchers built decision-making models to understand better and optimize the interface between the two.

The findings, according to Professor Panos Papalambros, the program's director, "essentially prove quantitatively that there is a significant link between manufacturing quality and product performance. For the first time now, we have a way of putting numbers to how much manufacturing quality affects performance, fuel economy and emissions.

HCCI: SYNERGY FOSTERS SUCCESS

The Multi-University Consortium on Homogeneous Charge Compression Ignition (HCCI) Engine Research, funded mainly by the Department of Energy with additional resources contributed by automotive industry partners, completed its third year. U-M leads the consortium, which also includes Massachusetts Institute of Technology, Stanford University, University of California at Berkeley and Texas A&M University. The objective is to understand the fundamental chemical and physical processes involved in HCCI combustion and to develop a working HCCI control strategy for multi-cylinder engines. Because there is no direct trigger for ignition, ignition timing can be all over the map, depending on the temperature of the engine and the intake charge. Practical implementation has so far been prevented by the complex interaction of both thermal and chemical kinetic factors that determine autoignition.

Synergism among the four universities involved in the consortium "really paid off this year by making good use of teams and individual core competencies at participating institutions," said George Lavoie, a visiting research scientist actively involved in integration efforts. This project balances more fundamental experiments and simulations with engine work. Experiments in the shock tube and the rapid compression facility support chemical kinetic studies, while engine set-ups provide insight into mixing, ignition, combustion, heat transfer and emissions, as well as subsequent demonstration of control techniques. Analytical work is being carried out in fundamental combustion, full cycle engine models and at the engine system level. These investments bring ME to the threshold of controlling single and multi-cylinder HCCI engines.



CFD temperature map showing combustion progress in an HCCI engine.

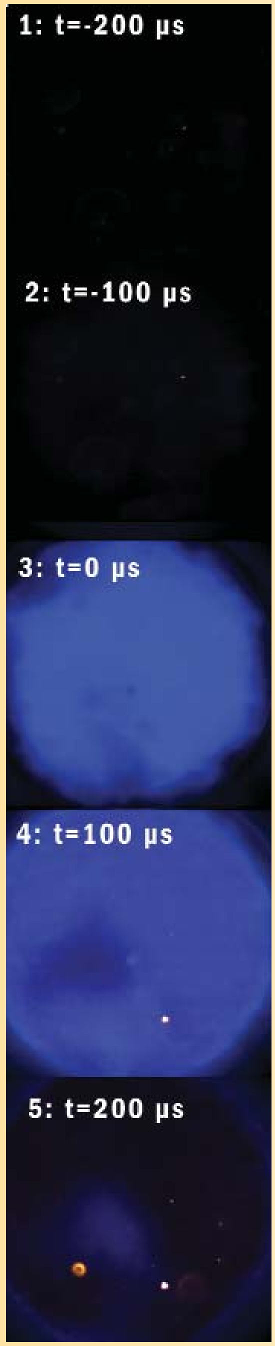
High-Speed Flame Imaging

Many types of optical diagnostic and imaging techniques have been used by researchers to investigate the combustion processes important in internal combustion engines. The progress of chemical reaction is especially important to understand in homogeneous charge compression ignition (HCCI) engines, where ignition is more difficult to control and ignition is dominated by chemical reaction kinetics. Yet, HCCI engines offer several advantages over traditional diesel and spark ignition engines. In particular, HCCI engines have the potential for greater fuel economy with simultaneous decreased nitrous oxide and particulate emissions.

Previous researchers have proposed that flame structures are only present at certain combustion conditions. However, there are limited data to support the regimes of homogeneous ignition versus flame propagation. Using the Rapid Compression Facility in the laboratory of Associate Professor Margaret Wooldridge, she and her research group have used high-speed (greater than 25 kHz) digital imaging to characterize autoignition of iso-octane over a range of operating conditions relevant to HCCI engines. The group's work defines limiting regimes in the way that combustion gases burn in an engine. There are "remarkable differences" between the regimes, according to Wooldridge.

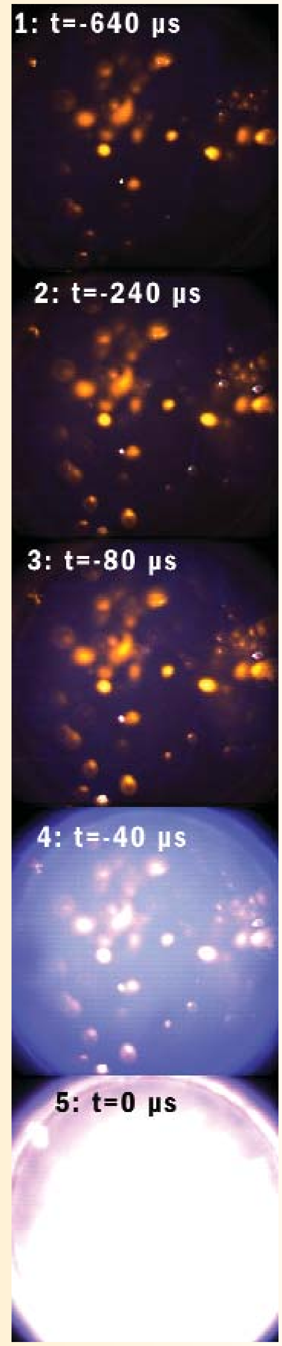
The high-speed images acquired this year in her lab are unique.

"We expect the results will have a profound impact on the combustion community as they reveal dramatic changes in flame propagation in different reactant composition regimes — results which have never been previously documented directly," she said. "We anticipate that the imaging data will serve as the basis for theory and model development and validation for years to come."



Typical ignition sequence for ϕ = 0.4, 10,000 fps, 90 μs exposure.

Typical ignition sequence for ϕ = 0.6, 25,000 fps, 19 μs exposure.



Typical ignition sequence for ϕ = 0.8, 25,000 fps, 19 μs exposure.

Hydrodynamic Sound Source Localization

Underwater noise is a serious concern for the U.S. Navy, according to Associate Professor David Dowling, whose work on sound source localization has received funding from the Office of Naval Research.

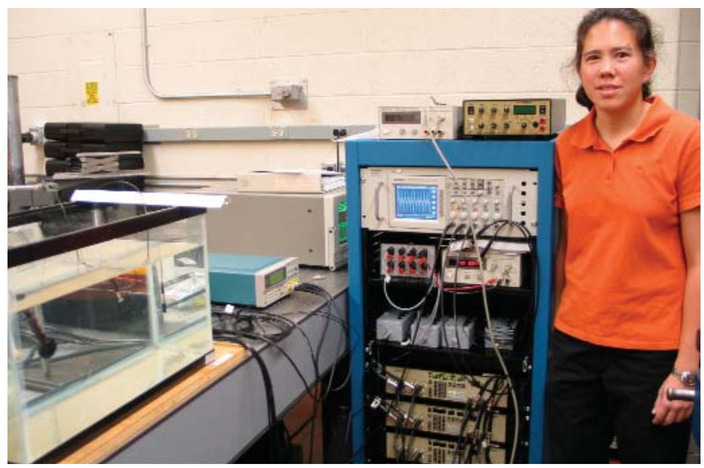
Unintended noise from ships, submarines or other naval vessels make them vulnerable to detection by enemy sonar. Ideally, the source of unintended noise should be localized during the research phase of naval hardware development. At that point, corrective design measures can be taken before production begins and before deployment, where operating costs and modifications can exceed many millions of dollars.

The worst offender in terms of noise, said Dowling, is cavitation, which occurs when small bubbles form in liquid because the pressure has been brought low enough that vapor can form. It commonly occurs around lifting surfaces, such as propeller blades, where pressure is high on one side and low on the other. It's the formation and collapse of those bubbles that creates a large amount of noise, but when cavitation first begins you can't see it, said Dowling. "That's the point of most interest to us, because it's the boundary between 'quiet' and 'noisy,' and we want to open the quietly-operating envelope as far as possible."

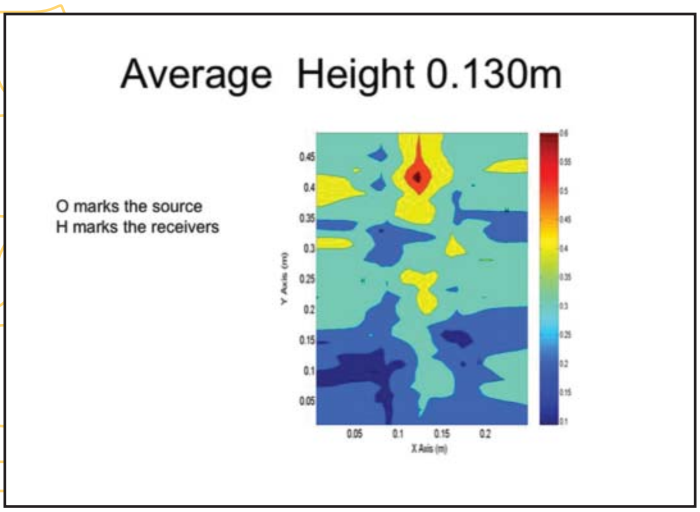
Graduate student Natasha Chang is working with Dowling to use 16 hydrophones attached to the test section of the water tunnel in Professor Steven Ceccio's laboratory. Sound typically moves in two directions, so hydrophones measure the sound that comes forward from the source, and signal processing routines then try to run it backward in time in order to localize the sound source. "Sound goes forward in the water tunnel and backward in the computer. The challenge here is telling the computer enough about the acoustic environment so that this can work," Dowling said.

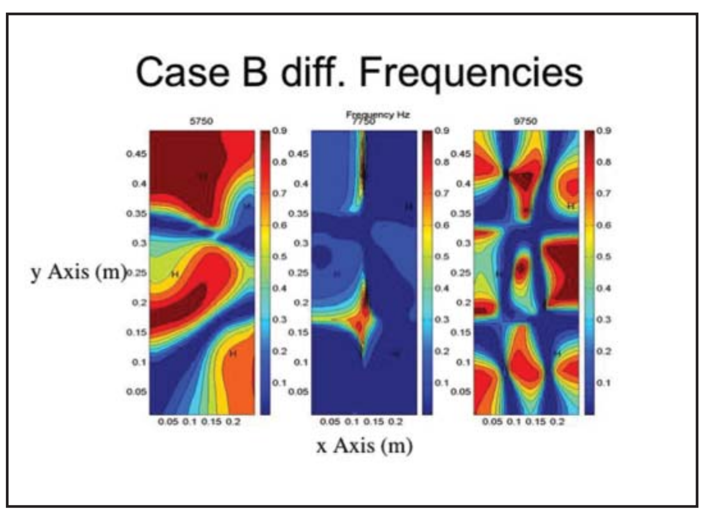
Developing the acoustic model is easier for longer sound waves, and the group is working its way from simple fish tank experiments at low-frequencies to more complex water tunnel experiments at high frequencies. The fish tank work is merely a stepping-stone to modeling the characteristics of the water tunnel. Lower frequencies provide robust results while higher frequencies allow for greater localization precision; thus, the hope is to use as large a bandwidth as possible to reap both benefits. "We're up to 10 kilohertz now," he said.

Once the signal processing routines are developed and testing at U-M is complete, Dowling hopes to continue experimentation at larger Navy facilities in Maryland and at the world's closed loop water tunnel in Tennessee. As part of the project, Dowling is collaborating with Ceccio, who is studying the fluid mechanics leading to cavitation.



Graduate student Natasha Chang (above) shows her experimental setup. Using a sound source and several receiving hydrophones, Chang collects sound data from her test setup to predict the location of the source. The process is repeated at several different frequencies and the outputs are averaged. The bottom left plot shows results from a single source, while the right plot shows results using several sources. The higher the frequency, the greater the accuracy: blue indicates poor correlation and red indicates strong correlation.





NEW DEVICE TO DETECT DYSPHAGIA

In conjunction with the NASA Biological Modeling Center, headed by Professor James Grotberg in Biomedical Engineering, Professor William Schultz is investigating the mechanical properties of saliva and swallowing.

Though humans don't give much thought to it, saliva is what they ingest most. It's a "miracle super lubricant" comprised of water, electrolytes, mucus, enzymes, hormones, antibodies, bacteria and other substances, said Schultz. It retards tooth wear and decay, helps maintain gum health and aids in wound healing, digestion and swallowing. It also presents opportunities for diagnostics, including potential screening for fertility, alcohol, HIV, gingivitis, bone loss and DNA damage that might indicate cancer.

Its analysis has particular relevance to astronauts who begin to lose bone mass in microgravity and who may also be at increased risk of cancer as a result of exposure to deep space radiation from long-term space travel.

When saliva "goes down the wrong pipe" — the trachea instead of the esophagus — it can result in aspiration pneumonia. Risk factors are many, including being bedridden, elderly, having neck surgery or radiation, multiple sclerosis, Parkinson's disease and 'dry mouth,' which is a common side effect of many prescription medications.

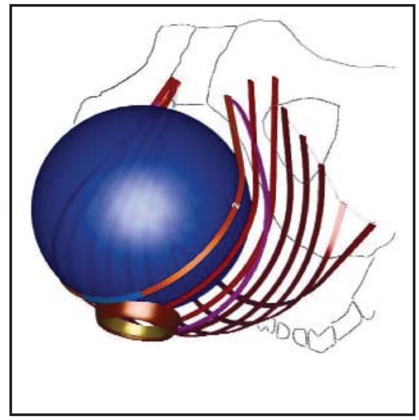
Zero-gravity is also a risk factor for aspiration pneumonia. "Astronauts don't have gravity to help them swallow," explained Schultz. Microgravity also causes redistribution of body fluids, so there's more water in the head and neck region. This in turn affects the pharynx, a muscular tube that determines down which 'pipe' ingested substances will go. Studying the pharyngeal region is challenging, though, according to Schultz. There is a three-phase flow of air, liquid and solids in a complicated geometry. And while part of the process is voluntary, some aspects of every swallow and such events as gag reflexes and vomiting are involuntary.

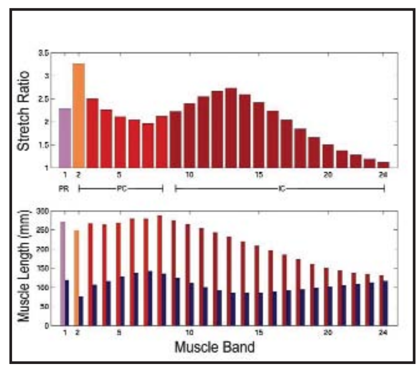
In response to the challenges posed, Schultz and collaborators Margaret Terpenning, MD, assistant research scientist with the Institute of Gerontology, George Taylor, DDS, assistant professor of dentistry, and Joe Murray, chief speech pathologist at the VA Ann Arbor Healthcare System have developed a simple test to screen for dysphagia, or improper swallowing. Subjects are given a small sample of ethanol to swallow and then asked to breathe into a breathalyzer. Residual alcohol elevates the readings and indicates a possible swallowing disorder. The test requires little operator training and is inexpensive and safe for those being screened. The device has application to a variety of diseases and conditions on Earth and in space, especially for the elderly and others with swallowing disorders.

PREVENTING MATERNAL INJURY

Between 10 and 15 percent of first time mothers are injured during childbirth. Their injuries often lead to urinary incontinence and pelvic organ prolapse, conditions that interfere with quality of life and worsen with age. With colleague John O.L. DeLancey, MD, professor of obstetrics and gynecology, and Janis M. Miller, assistant research scientist in the School of Nursing, ME Research Professor James A. Ashton-Miller is investigating the biomechanics of such injuries. Their work is part of a $5.6 million, five-year award from the National Institutes of Health.

Kuo-Cheng Lien, an ME doctoral candidate in ME mentored by Ashton-Miller, has developed a computer model of the structure-function relationships in the female pelvic floor during vaginal birth. The model simulates the stretch in each band of pelvic floor muscles as a sphere, equivalent in size to a 50th percentile fetal head, passes through the simulated birth canal. The model captures the initial length of each muscle band and the maximum length reached during the birthing process. One muscle band in particular stretches to more than three times its original length during birth, and therefore is at a greater risk of injury than any of the other muscles.





James Ashton-Miller and colleagues have developed a computer model to simulate vaginal birth, starting at the beginning of the second stage of labor. At top is a screen capture from the simulation, which demonstrates how the muscles stretch. The plot below shows the maximal length achieved by each muscle during the second stage. From this data, researchers are extrapolating which muscles are the most likely to suffer injury during childbirth.

Ashton-Miller and his team have validated the model using clinical evidence from magnetic resonance images. These images showed injuries in precisely the region of the pelvic floor muscles where the model predicted the largest stretch ratio. The research has earned the 2003 Prize Paper Award from the American Urogynecological Society. The findings will help identify areas of future research in order to prevent and treat childbirth-related injuries.

A large electrokinetic pump.

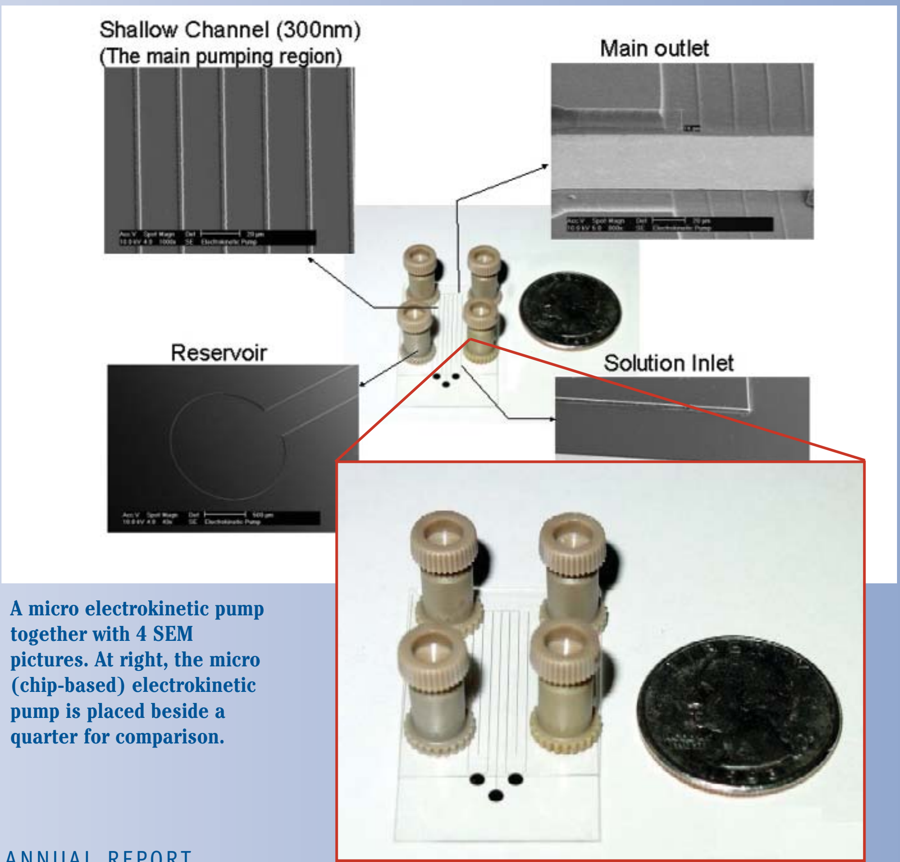
Electrokinetic Pump to Help Patients Suffering from Hearing Loss

Nearly 30 million Americans of all ages suffer from some degree of hearing loss. For some, hearing can be improved through cochlear implants, electronic devices that turn sound waves in the air into electrical impulses that are sent to the brain. Since the cochlea is shaped like a small snail shell — about 9mm across the base, and about 5mm tall from base to apex — inserting implants can be challenging for surgeons. Typical implants can only be placed a limited distance into the cochlea, often less than one turn of the two and three-quarters turns that comprises the entire cochlea. This results in the implant only being able to excite a limited range of frequencies, precluding hearing higher-frequency sounds, such as sirens or high-pitched voices.

As part of the Wireless Integrated MicroSystems Engineering Research Center (WIMS ERC) at U-M, Assistant Professor Ernest Hasselbrink and graduate student Meng-Ping Chang are helping to tackle this problem. The strategy is to use a multi-chamber fluid-filled backing device, built by collaborators at Michigan Tech, which is pre-curved to the shape of the cochlea. By pressurizing the chambers of this device, its curvature can be precisely controlled (the device extends in a manner similar to a New Year's eve party favor). Hasselbrink and Chang have developed a high-pressure electrokinetic pump that provides the hydraulic pressure, which can be actively controlled during insertion by varying voltage applied to the pump. The pump operates off of 10 volts and has no moving parts.

Hasselbrink and his team have built a large-scale electrokinetic pump and have demonstrated proof of principle. The next step is to reduce its scale so that it can be integrated into a microchip, which would allow it to fit on a pen-size surgical tool.

"This is an interesting project for me for two reasons," Hasselbrink said. "First, it has a real impact on real people. If our success so far continues, we will have helped make a major advance in hearing aid technology, with a truly interdisciplinary, multi-institution team. Second, it's a new frontier for microfluidics research. This represents a return to core mechanical engineering — doing hydraulic work, but on the nanoliter scale."

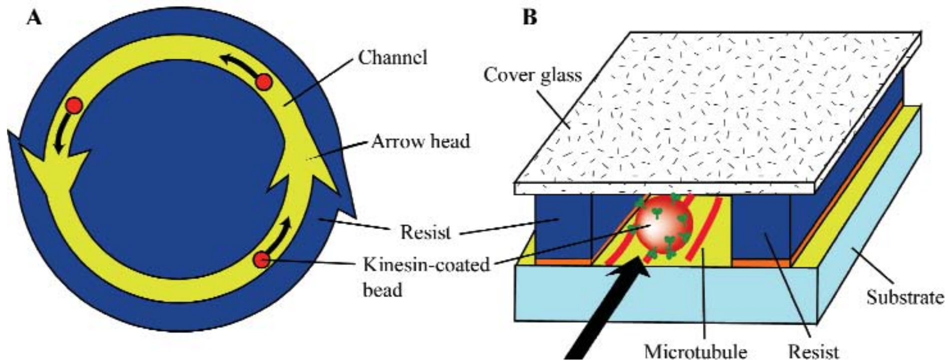


A micro electrokinetic pump together with 4 SEM pictures. At right, the micro (chip-based) electrokinetic pump is placed beside a quarter for comparison.

Molecular Biology Fuels Nanotechnology

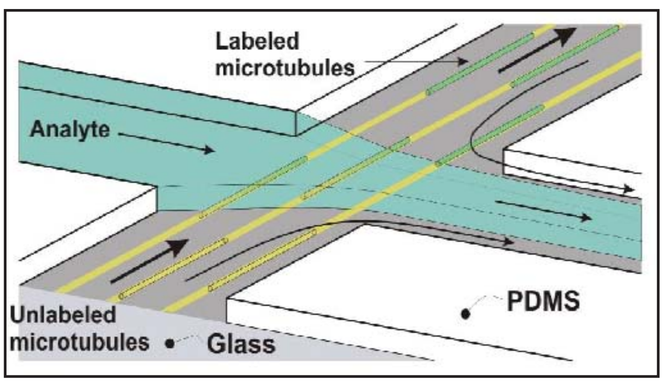
Biology is the pioneer of nanotechnology, according to Associate Professor Edgar Meyhöfer.

"Every single cell in our body contains, in the form of DNA, the complete information to build our entire body," he said. "The human DNA consists of about 3.2 billion base pairs that encode about 30,000 different genes. Stretched end-to-end, the DNA from one cell is about a meter long, yet it's all packed into the cell, and the right information is retrieved at the right time. That means biology has machines that can achieve some very complex tasks."



Self-fueled microscale fluidics pump. Fluid motion in the device is induced by the kinesin-driven motion of beads in pump channels.

Meyhöfer's goal is to utilize nano- and microfabrication techniques and create engineered environments that are suitable for the functional integration of biomolecular engines. The vision of this strategy is to develop revolutionary nanotechnology by taking advantage of the unique properties of biomolecules.



Kinesin and microtubule-based biomolecular sorter. The functions of this device include separation, concentration and diagnosis chemicals and pathogens. Antibody-functionalized microtubules bind and detect target molecules as they are transported through a complex analyte stream.

Biomolecular motors or motor proteins, a group of biomolecules that use chemical energy from the cell and transduce it into mechanical work, are prime candidates for such technological applications. "These motors are very efficient," said Meyhöfer. For example, in cells they transport organelles and synaptic vesicles using fractions of an attowatts of power. There is a "huge diversity" of these molecules within cells in order to ensure that other molecules, organelles and cellular constituents are distributed to the right locations at the right times, which is critical for the functioning of highly organized systems. Without these intracellular machines, diffusion could not be overcome. Cells wouldn't divide properly; sperm couldn't swim; and muscles wouldn't contract as they should, to name just a few.

To achieve the vision, teamwork is crucial. Meyhöfer works with Assistant Professors Alan Hunt and Joseph Bull in Biomedical Engineering, Assistant Professor Jay Guo in Electrical Engineering and Computer Science, and ME Assistant Professors Katsuo Kurabayashi and Charlie Hasselbrink. "Drawing from the expertise of faculty from three departments makes us more efficient and is what drives this work, which spans the breadth of bio- and engineering science from cell biology, biochemistry and biophysics to micro- and nanofabrication, microfluidics and theoretical fluid dynamics."

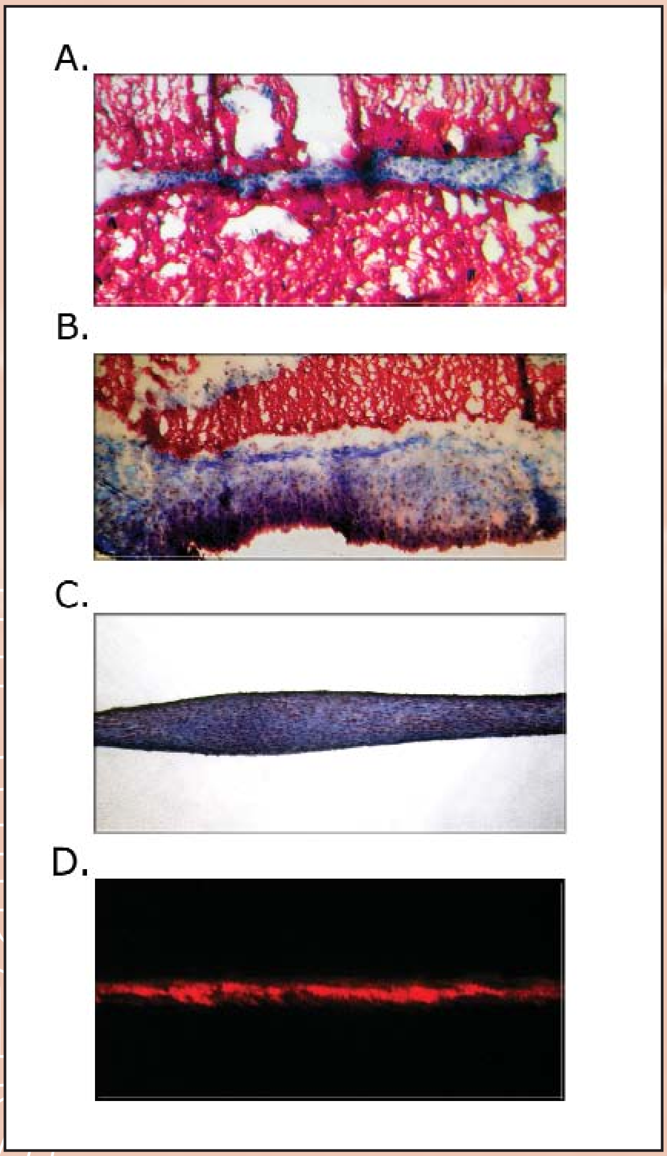
Using the microtubule-based motor molecule kinesin the group has developed a molecular sorter prototype. Potential applications include detecting biological warfare agents as well as viruses and bacterial infections, all from a small blood and/or saliva sample — in essence, a diagnostic laboratory on a chip. Using nanoimprinting and fluorescent-labeled test molecules, nanomolar concentrations of analyte have been detected, and Meyhöfer expects to detect femtomolar concentrations shortly.

The team has also developed a micrometer scale microfluidics pump, which can work in tandem with the sorter, transporting fluid samples. The ring-like structure of this device can also be used to power microscale rotary engines. One plan calls for utilizing this device for serial readouts as it rotates. The structure improves signal-to-noise ratio and reduces false-positive findings, explained Meyhöfer, and it allows the analysis of multiple agents at the same time.

The pump is self-actuated and fueled. The sorter has an extremely low power requirement, running on a femtowatt. Low energy needs and the low cost of fabrication at the nanoscale mean that one day there will be "no problem in giving one to every person in the world."

Tissue Engineering Provides Insight into Tendon Growth

With approximately 15 million tendon injuries each year in the United States, as well as damage to tendon tissue from aging, diabetes and other conditions, scientists are seeking a better understanding of adult tendon development and repair. At U-M, Associate Professor Ellen Arruda, Assistant Professor Robert Dennis and Assistant Research Scientist Keith Baar have developed new ways of engineering tendon tissue, which they then study under a variety of conditions to learn more about how cells generate new tissue.



Formation of an engineered tissue is shown stained with Masson's Trichrome: a tendon at 7 days (A), 14 days (B), and 21 days (C). Over time the fibrin (shown in red) is digested and the cells (grey) produce their own collagen (blue). At the end of the three weeks the tissue is very similar to an embryonic tendon: all collagen and cells. The bottom image is a picosirius red stain of the 21 day engineered tendon, showing that the collagen is birefringent (oriented and organized).

The team developed a method for the self-organization of cells into a three-dimensional tissue structure or "construct" without the use of artificial scaffolding. Most traditional tissue engineering uses a polymeric or other artificial (as far as the cells are concerned) structure that is then 'seeded' with cells. These cells recognize this environment as mature and therefore do not replicate or produce their normal response to mechanical straining that would lead to growth. "In our approach, the cells generate their own extra-cellular matrix — which is largely collagen — they then manipulate it into organized, aligned fibrils which are the structural units in tendon. In this manner the cells are building a native tendon morphology by recapitulating the embryonic state," explained Arruda.

The team has also developed a fibrin gel system, which "is a good material for engineering tissues because it's matter that cells will move into and replicate within," explained Baar. "The nice thing about this is not only do we make the tendon structure but we also have it produce its own matrix. It allows for us to measure how much matrix is produced as well as the capacity for cells to grow and their response to stretch that is difficult to measure if you have a lot of collagen (about 70 percent of normal tendon tissue is collagen). We've made tissue with more cells and less collagen so we can see what's going on."

Using a functional bioreactor developed by Dennis and Baar, the team stretches the band-shaped tendon constructs for a variety of times — from a few minutes to days — and measures the effects on the functional capacity of the cells to generate new collagen. The group has found that when tendon structures are stretched for a period of seven days, they produce two to three times as much, making the tissue that much "thicker, healthier and more robust," said Baar.

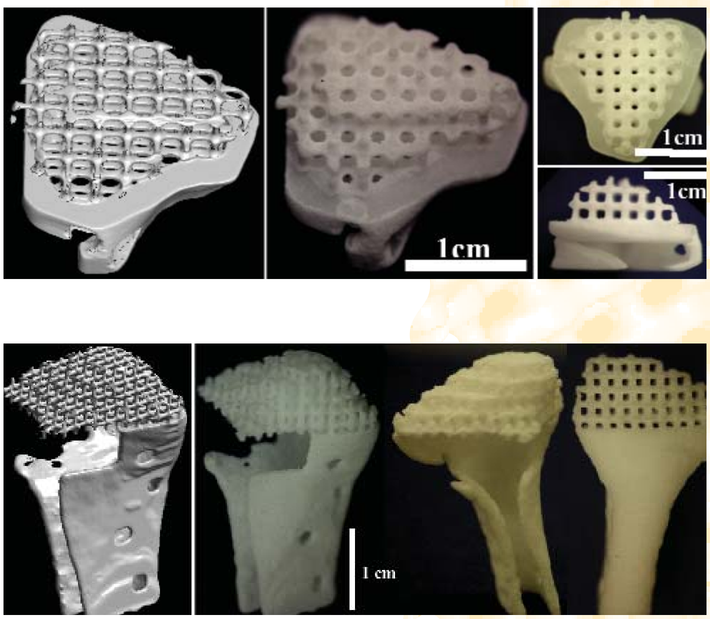
The next step "is to start to ask which genes are being activated and what signaling pathways are activating them," said Baar. The team has already identified a number of signaling molecules that become active in tendon cells following stretch — some after as little as five minutes. Right now researchers are working to identify the genes activated by those signaling molecules, how they are translated into the proteins that comprise the tendon and how these changes have have a longer-term effect on tendon tissue.

"If we understand what signaling is required to make tendons stronger, we may be able to apply it to human biology and prevent a lot of tendonopathy and rupture," said Baar. It may serve another purpose as well: "I'm not saying we're ready for transplants at this point, but that would be a long-term goal."

Laser Sintering Improves Bone Tissue Engineering

More than one million surgical procedures are performed annually in the U.S. to repair damaged or fractured bone. Standard treatment, which is expensive, includes surgical reconstruction and the use of mechanical devices, but there are risks: prostheses may malfunction and require replacement; donor tissue may be rejected by the host or it may transmit disease, and mechanical devices can't always perform all of the functions and movements of their natural counterparts.

Tissue engineering is an alternate approach that involves techniques focused on the repair and reconstruction of damaged or diseased organs and tissues. Tissue engineering holds promise for improving current methods of treatment, but it has limitations as well. Research has shown that isolated cells upon implantation are unable to form physiologically and mechanically viable tissue in the absence of a porous, bioresorbable scaffold. As a result, scaffold design and fabrication for engineered tissues is an active area of inquiry, and one where Assistant Professor Suman Das, his research group and his collaborators have successfully applied solid freeform fabrication (SFF) techniques, specifically selective laser sintering (SLS).



Top (left to right): 3D rendition of a minipig mandibular condyle scaffold design; actual PCL scaffold produced by SLS; top and side views of PCL scaffold. Bottom: (left to right): 3D rendition of human condyle scaffold design #2; actual PCL scaffold produced by SLS

Among the requirements of engineered tissue scaffolds are biocompatibility, porosity and permeability, suitable surface chemistry and surface texture to enable cell attachment and proliferation. Such scaffolds must serve as temporary replacements, providing mechanical support for sustaining stresses and loads normally encountered by the lost tissue. They must also degrade and resorb into the body at the same rate that new tissue grows. Finally, such scaffolds must be able to replicate complex anatomical shapes.

While conventional scaffold fabrication techniques have numerous limitations, SLS offers the potential for making geometrically complex scaffolds directly from computer models or digital imagery such as computed tomography (CT) or magnetic resonance imaging (MRI) scans. SLS processes can bypass labor-intensive, time-consuming conventional manufacturing processes that often require the use of toxic solvents while providing little control over geometry and the types of scaffold materials that can be used.

In SLS, a three-dimensional digital model of the scaffold is mathematically sliced into a number of thin layers. The scaffold is then created by selectively laser sintering the 'sliced' patterns into sequentially deposited layers of a biopolymer powder. Das and his group have fabricated proof-of-concept scaffolds for human and minipig mandibular condyles using polycaprolactone (PCL), an FDA approved bioresorbable polymer that has been found suitable for the repair of craniofacial defects. These scaffolds were created directly from computationally-optimized digital designs developed by Associate Professor Scott Hollister. Using an optimized model based on nonlinear programming techniques, the scaffolds incorporated complex internal geometries and porous architectures. Through the use of optical microscopy, they were found to be structurally sound, dimensionally accurate and more than 99 percent dense, attesting to SLS process capability. The scaffold design and fabrication process combines computationally optimized scaffold designs and solid freeform fabrication techniques. It has the potential to offer scaffolds and other bioimplants that are custom-made to individual patients' needs in a variety of biomaterials.

This research is funded by the National Institute of Dental and Craniofacial Research of the National Institutes of Health. The team includes Das, graduate students Brock Partee and Jessica Williams, and collaborators Scott Hollister, associate professor of Biomedical Engineering, Mechanical Engineering and Surgery; Stephen Feinberg, professor and director of Oral and Maxillofacial Surgery; and Paul Krebsbach, associate professor of Oral Medicine, Pathology and Oncology.

S.M. Wu Manufacturing Research Center

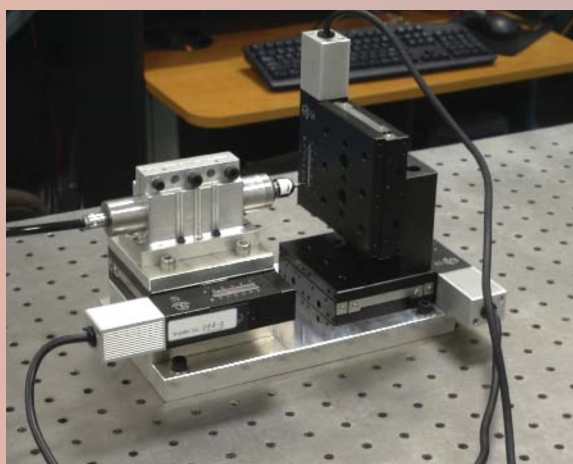
Over the past year, industrial leaders and scholars from all over the world visited the S.M. Wu Manufacturing Research Center, which is known for its research in manufacturing science and engineering. The center's six laboratories conduct work in assembly and materials joining, drill research, in-process quality improvement, machine tools and machining, micro/meso manufacturing and systems, and sheet metal stamping and material forming.

Senior executives from companies such as GM, Ford, DaimlerChrylser, Baosteel, NSK, Rockwell Automation, Samsung Electronics and Delphi Group "came to visit the center and to discuss developing partnerships with us," explained Professor Jun Ni, director. "There's been a lot of collaboration."

The center also held the 6th Wu Symposium & International Conference on Frontiers of Design and Manufacturing at Xi'an Jiao Tong University in Xi'an, China, in June. More than 600 people participated in the internationally renowned event. Graduate student Zhenkua Huang, working with Associate Professor Albert Shih and Ni, earned a best paper award at the conference.

The first phase of a DARPA-funded project on micro internal combustion swing engines for portable power generation systems — headed by Ni — was completed. His research group successfully developed a prototype engine that can generate 30W electrical power output. A phase two DARPA project has already been approved to continue this research program. Other projects, funded by the Department of Energy, include chipless holemaking using frictional heat generation, hybrid vehicle thermal management using high-thermal conductivity lightweight carbon materials, and microforming techniques for fuel cell processors.

Research funded by GM and other automotive and materials companies continues in the areas of variation and springback reduction of aluminum and high-strength steel and on advanced forming technologies including hydroforming of tubes and sheet metal and warm forming of lightweight materials.



A meso-scale 3-axis milling machine.

The National Science Foundation recently granted funding for a new Industry/University Cooperative Research Center (IUCRC) on precision forming, in collaboration with Ohio State University. Industry partners will include automotive companies, OEMs, suppliers and materials companies. This is ME's third IUCRC. The first is the Center for Dimensional Measurement and Control in Manufacturing, and the second is the Center for Intelligent Maintenance Systems.

The exceptional skills and talents of the center's researchers have been recognized in other venues over the past year. Awards are listed on page 46.

SMART MACHINES

Reducing maintenance costs is one of the manufacturing sector's highest priorities. Downtime can cost manufacturers $20,000 per minute and perhaps even more in assembly plants.

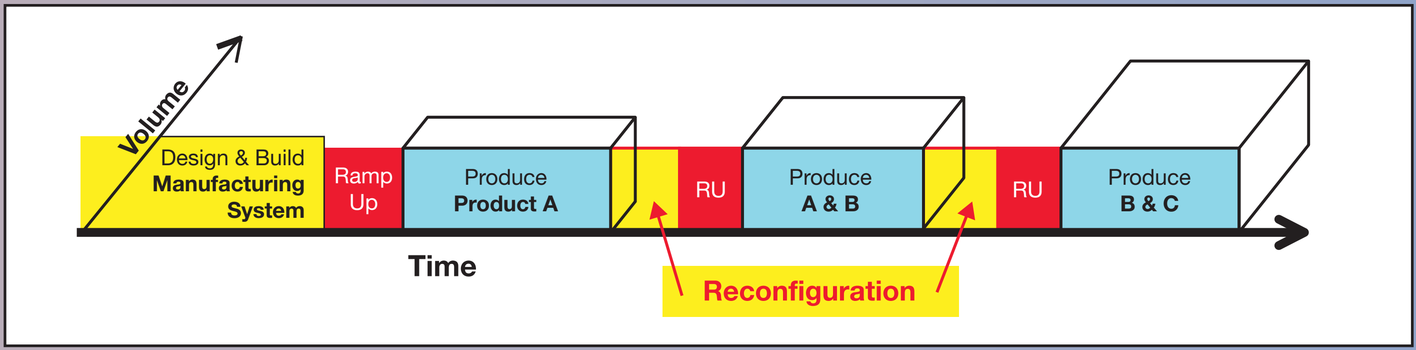
"If you have to bring a piece of equipment down for two hours, you can do the math," said Assistant Research Scientist Dragan Djurdjanovic. "It represents a huge loss."

Djurdjanovic leads the Watchdog Research Team at the Center for Intelligent Maintenance Systems (IMS), a National Science Foundation Industry/University Cooperative Research Center (IUCRC) in collaboration with University of Wisconsin, Milwaukee. At the U-M, the center is under the auspices of the S.M. Wu Manufacturing Research Center. Djurdjanovic's work involves examining methodologies for multi-sensor assessment and prediction of equipment performance — in the manufacturing and service sectors alike — in order to facilitate proactive and optimal maintenance.

One "toolbox" of methodologies, Watchdog Agent (tm), is of particular interest to auto manufacturers. Algorithms based on input from sensors monitor cars while they're driving in order to predict and diagnose faults. Since faults tend to manifest themselves while cars are running, accelerating or braking, the algorithms are more successful in identifying problems that conventional diagnostic tests can easily miss. The project will continue for the next five years.

Expanding on the work of the Center for IMS, Djurdjanovic and ME Professor Jun Ni and Julie Simmons Ivy, assistant professor in the U-M Business School, are exploring responsive maintenance in reconfigurable manufacturing systems. For years, manufacturers have used reconfigurable systems to meet demand changes.

"Now we're trying to use the assets of these systems to our advantage," said Djurdjanovic. "Reconfiguration as a maintenance action is our novelty. It can be utilized to our advantage when maintenance is required in response to equipment degradation, while still meeting production goals." The National Science Foundation is funding their work.



During its lifetime the RMS will be reconfigured many times to adapt to the market in terms of production volume (changed capacity) and products produced (changed functionality).

Towards Process-Driven Products

Globalization is causing a dramatic transformation in the way that manufacturing companies approach product and process design. The era of "product-driven process" is over; multi-stage manufacturing systems (namely the processes) are not designed anymore to produce single products. Rather, each manufacturing system in the 21st century is designed to produce a product family, and not a single product. The lifetime of this manufacturing system will be, as before, some 10 to 20 years, but instead of producing always just a single product, during its lifetime period the system will be reconfigured many times to produce upcoming products (of shorter lifetime), all of the same product family.

With this new approach, an expensive multi-stage manufacturing system for a product family already exists in the factory, and therefore designers must fit the design of each new product to the structure and capabilities of the available system. In other words, the designers must design "process-driven products," an approach which, although imposing new constraints on the product design, is making the products less expensive. To adapt the manufacturing system to the production of a new product, several stages in the system might be reconfigured to fit new needed functionalities. Manufacturing systems will undergo several reconfigurations during their lifetime, where a short ramp-up period must follow each reconfiguration (see figure above).

Many enablers of this revolution in product-process design approach were developed at the NSF-sponsored Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS). These include system reconfiguration design methodologies, life-cycle economic model, a science-based ramp-up methodology that is already in use by industry, and innovative hardware prototypes of a reconfigurable machine tool and a reconfigurable inspection machine (RIM). The ERC/RMS holds 10 patents in the emerging RMS field.

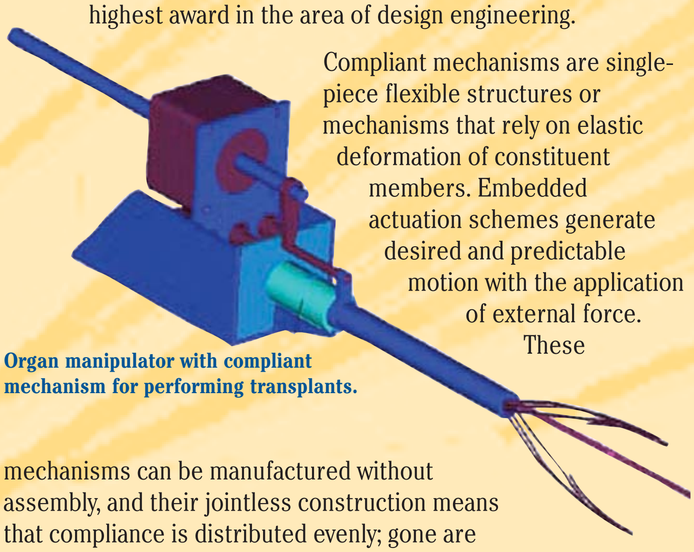
The RIM's physical architecture is reconfigurable with sensors that can be redirected to scan a whole family of similar parts so that it can continue to be used as future generations of parts come along. Researchers at the ERC/RMS have developed the scanning algorithms, the optical techniques, the human/machine interface, and the knowledge-base derived using the RIM. The research is advanced enough that an industrial-grade prototype is currently deployed at one of our partner's manufacturing facilities. It is another example of the center's continuing effort to apply advanced science to manufacturing and dramatically change the way manufacturing works.

This vision of a "living" factory that can be rapidly and cost-effectively reconfigured exactly when the market requires a change offers an important economic advantage to companies. Because reconfiguration enables the capacity of a factory to be rapidly changed, there is no need to hold extra inventories. And because reconfiguration enables changes in the system functionality to produce new products needed by consumers, there is no need to build so many factories and production systems dedicated to specific products. The process-driven product practice combined with RMS technology has, therefore, enormous economic value with a broad impact on society.

This vision of a "living" factory that can be rapidly and cost-effectively reconfigured offers an important economic advantage.

Taking Cues from Nature

Professor Sridhar Kota's work in the area of compliant mechanisms and biomimetics, where principles from nature are applied to engineering problems, has led him to novel and practical developments across myriad materials, industries, disciplines and domains in micro, meso and macro scales. For his innovative work, Kota has earned the prestigious 2004 American Society of Mechanical Engineers Machine Design Award, ASME's highest award in the area of design engineering.



Organ manipulator with compliant mechanism for performing transplants.

Compliant mechanisms are single-piece flexible structures or mechanisms that rely on elastic deformation of constituent members. Embedded actuation schemes generate desired and predictable motion with the application of external force. These mechanisms can be manufactured without assembly, and their jointless construction means that compliance is distributed evenly; gone are problems due to wear, friction, backlash or lubrication. In military applications, it means a reduction in radar cross section. Mechanisms can be designed for desired stiffness and in a variety of materials, including titanium, aluminum, steel, nitinol and composites.

Much of Kota's work has been focused on developing design algorithms for systematically generating these optimal compliant structures for a desired shape change that meets such conflicting requirements. Six of his PhD students who worked in this area have assumed faculty positions at U.S. research institutions.

Kota has developed a novel approach to varying airfoil geometry by combining advances in topological optimization methods and kinematics. The simplicity and scalability of his approach enable the aerodynamic benefits of airfoil shaping to be realized without the high cost, weight, and supportability penalties of past concepts.

Some of the practical applied research and development efforts are being carried out at FlexSys, Inc., a company Kota founded a few years ago. Dr. Joel Hetrick, a former student, continues to turn these new concepts into practical realities as FlexSys vice president. Commenting on this applied research, Dr. Donald Paul, Chief Scientist-Air Vehicles Directorate, Wright Patterson Air Force Base, Ohio, said, "His approach is enabling for future morphing aircraft concepts and could revolutionize aircraft design. Professor Kota's compliant wing technology has matured through several successful wind tunnel demonstrations and is ready for flight demonstration — the final step toward transition to future aircraft."

Another aircraft application involves active flow control to prevent boundary layer separation in order to improve aircraft performance. Kota and Hetrick have developed an electromechanical flow control device that couples a high frequency piezostack actuator with a 65X compliant displacement amplification mechanism to oscillate 16 vortex generating blades at rates up to 250 hundred hertz. The device is scalable over a range of operating frequencies, compact and requires little power, about one watt per device. Wind tunnel testing has shown a lift increment of nine percent with oscillating versus static blades.

In collaboration with transplant surgeon Juan Renas, M.D., assistant professor of surgery at the U-M Medical School, Kota's students have designed an organ manipulator that uses a compliant mechanism for performing organ transplants and other surgical tools. The device will soon be prototyped using titanium and tested.

Kota's innovative compliant mechanisms are uniquely suited for MEM's unusual constraints. His work has enabled many successful three-dimensional MEMS devices in the past five years. According to MEMS pioneer Steven Rodgers of MEMX, Albuquerque, New Mexico, Kota's designs "enabled the creation of industry leading optical components with sub-milliradian angular repeatability with simple open-loop control. More amazingly, we have not detected hysteresis with Professor Kota's mechanical amplifiers even though we are sensitive to just a few angstroms of input displacement."

Piezo-compliant actuators embedded in an aircraft wing.

Because compliant design eliminates the issue of mechanical wear, during lifetime testing of the optical components, "MEMX recently passed one-half trillion total accumulated cycles without a single failure. Such levels of performance and endurance would have been unimaginable without Professor Kota's innovations."

research

Vegetable-Based Cutting Fluids

The story of cutting fluids is an old one in manufacturing history, dating back about a century, says Assistant Professor Steven Skerlos. Cutting fluids have been seen as "miracle fluids" due to their ability to boost productivity and extend the life of plant equipment.

For the past decade, Skerlos has been studying different aspects of metalworking fluids (MWFs), including vegetable-based alternatives to conventional petroleum products.

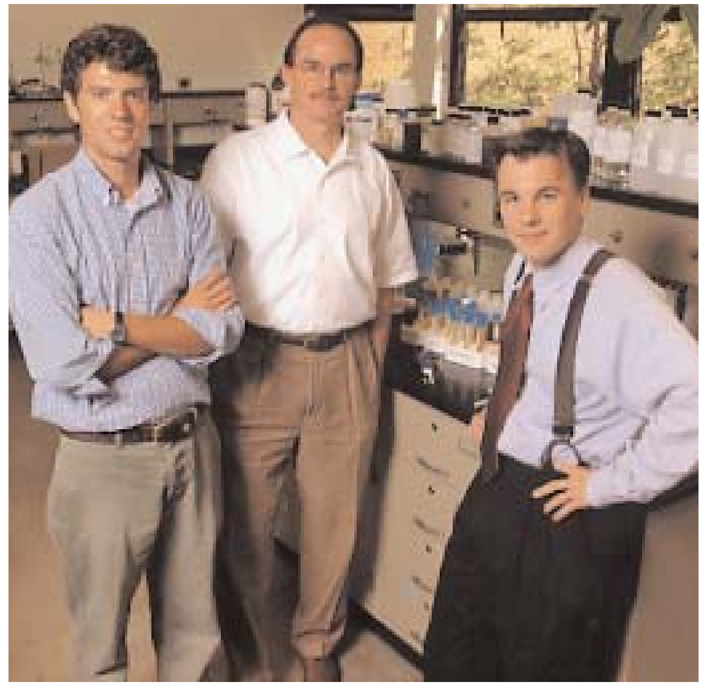
Formulations of MWFs have changed over time, in part because of questions raised about their impact on human health and in part due to higher demands placed on their performance. MWFs are comprised mainly of water, but typical MWFs contain a significant amount of petroleum oil and about 10 to 15 other ingredients, including rust inhibitors, surfactants and biocides, explained Skerlos. The complexity of MWF systems leads to cost, environmental, health and performance issues. Even national security enters the picture when the amount of petroleum consumed by MWFs is considered. By contrast, vegetable-based fluids garner positive responses when you consider questions of security, the environment, worker health and jobs for American farmers, said Skerlos.

Skerlos is now looking into the delivery of specialty additives — in particular, extreme-pressure additives — to make vegetable-based MWFs more viable on shop floors. He was awarded funding from the National Science Foundation/ Environmental Protection Agency Technology for a Sustainable Environment program to continue this work.

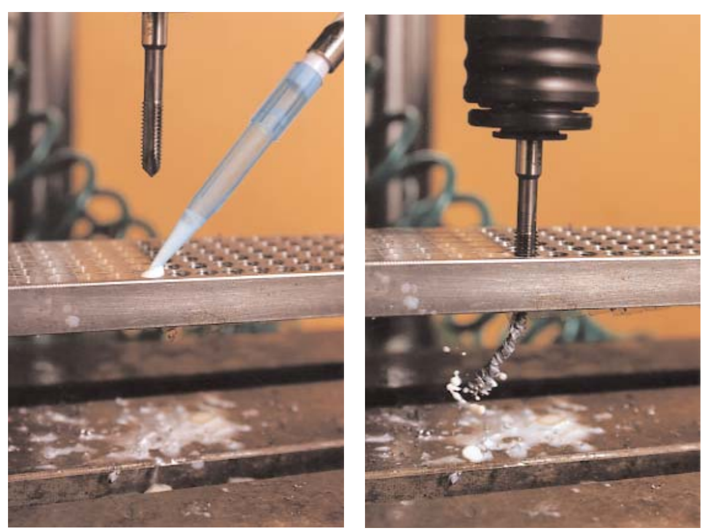
"In today's competitive manufacturing environment, there's a need to produce products faster, so you need to cut metal faster," Skerlos said. "Meanwhile, manufacturers are using exotic alloys, which puts more pressure on tools. You need to put extreme pressure additives in MWFs that allow you to cut under such conditions. We need to understand how they find their way to the interface of the tool and the work piece and how they work in vegetable-based systems so that cutting fluids work better with fewer toxic materials."

It's a complex process, and one that's not well understood even in petroleum-based systems.

Skerlos and graduate student Andres Clarens recently presented data comparing vegetable- versus petroleum-based oils for lubricity in MWFS at the Japan/USA Symposium on Flexible Automation. Their findings indicate that vegetable-based oils have better lubricity. The goal now will be to translate the higher lubricity of the vegetable-base oils into MWFs that can withstand extreme pressure conditions and last longer than traditional petroleum-based MWFs. "Once this is achieved, we will have simultaneously reduced costs and environmental impact in the machine tool industry," Skerlos said.



ME second-year graduate student Andres Clarens, Civil and Environment Engineering Professor Kim Hayes, and ME Assistant Professor Steve Skerlos.



Researchers test the performance of MWFs by using a tapping torque machine to drill holes in a steel work piece of a known hardness.

Self-Optimized Soft Landing Valves

Automotive engine improvements have involved removing mechanical linkages from the engine and replacing them with electronically-controlled devices that offer more flexible operation and thus allow optimal performance. For instance, spark timing, which used to be mechanically coupled to the engine is now controlled electronically. Katherine Peterson, a PhD student and Rackham Predoctoral Fellow, working with Associate Professor Anna Stefanopoulou, has been developing controllers for valve timing, which will allow for the development of super-efficient and robust camless engines.

"Currently, cam profiles control valve timing in the majority of vehicles," explained Peterson. "But what you want the valve to do when idling and when accelerating at 6,000 RPMs aren't the same. When engines are designed, there's a tradeoff: The cam profile works well at all speeds, but it's not working optimally at any." Changing the cam phasing allows some flexibility for optimization. Eliminating the camshaft and using an algorithm to electronically control the valves would allow for optimal timing at any RPM and load.

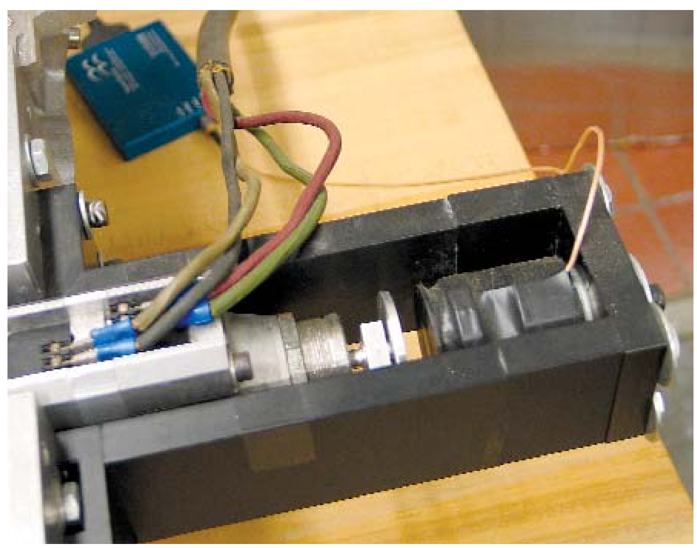
One such proposed technology involves the use of electromagnetically controlled valves. However, if the valves are not properly controlled, the system suffers from large, noisy impacts. "Think of the light switch in your office," said Stefanopoulou. "It clicks when you turn your office light on and off everyday. Now think of 16 similar switches (assuming you have 16-valves in your car engine) turning on and off 3,000 times per minute bearing 700 Newtons of force when you're comfortably cruising in your car at 40 miles per hour." The task can be arduous ... and deafening.

Peterson developed a system to use feedback during valve transitions — of about four milliseconds — to control the 8 mm motion of the valve and land it softly, at or less than 0.1 meters per second. Using sensors to measure valve position and current from the electromagnet, nonlinear control theory is used to determine the voltage across each coil to regulate the valve motion. But because no two actuators are the same, whether due to variance in manufacturing, settings or wear, Peterson developed a second feedback algorithm to measure how the valve has performed over time and adjust the controller as necessary.

"The nice thing is, the valves are opening and closing several thousand times per minute, so even if the algorithm takes 40 tries that's instantaneous from the driver's viewpoint," Peterson said. A controller has memory, where information is stored, so it remembers where it stopped. Next time the car is started, no adjustment is required.

The controllers have been tested in benchtop experiments at U-M and Ford. Peterson's PhD work has resulted in one patent and several citations in the academic and popular press. Peterson has accepted an assistant professor position at the School of Mechanical Engineering, Purdue University. Before joining Purdue (August 2005), she will be in Australia and Sweden applying her control results on power converters and implantable drug delivery systems that depend on fast electromagnetic switches.

Kathy Peterson (top) discusses her experimental setup of an electronic valve timing controller. Below is a closeup shot of the controller.



POSITION ESTIMATION SYSTEM FOR MARS ROVERS

Research Professor Johann Borenstein, Research Investigator Lauro Ojeda, Visiting Scholar Giulio Reina, and Visiting Research Investigator Daniel Cruz have successfully completed a three-year project funded by NASA to develop a Proprioceptive Position Estimation system to be considered for use on its 2009 Mars Rover mission.

In order to develop and test the system, researchers needed a robot, so they assembled a team of 20 undergraduates and volunteers from the professional engineering community to build the Fluffy Mars Rover, a fully functional half-scale kinematic duplicate of the actual NASA Rocky-8 and Fido-class Mars Rovers.

Unlike the Earth, which is surrounded by a network of satellites that beam signals back to GPS systems, Mars has no such network. So a mobile robot like a Rover has to have an entirely different navigation system that doesn't require external signals, explained Borenstein. Odometry can step in to provide some much-needed navigation information, but on Mars where the terrain is sandy and rocky and wheels often slip, "it fails you miserably because a complete revolution of the wheels doesn't translate into a certain distance traveled."

Fluffy Mars Rover

In response to the problem, Borenstein's team developed a series of wheel slippage indicators that rely on sensors such as gyros, accelerometers and wheel encoders. Once it's determined that there has been slippage, a second subsystem looks at the indicators in light of other parameters, such as terrain slope and on-board current consumption, and determines with a high degree of accuracy how much error was introduced by slippage, thereby allowing the localization system to adjust its calculations.

Borenstein has submitted the system to NASA. He expects that the agency will choose one from among those submitted by 2006 or 2007.

DARPA CHALLENGE

In March, Research Professor Johann Borenstein spent a week in the Mojave Desert, serving on the Independent Technical Evaluation Team (ITET) of the Defense Advanced Research Projects Agency (DARPA) Grand Challenge. Designed for the purpose of speeding research and development of autonomous ground vehicles, the first Challenge drew individual participants and organizations from academia, industry and even the backyards and garages of hobbyists and amateur roboticists around the U.S.

Along with Professor Ronald Arkin of Georgia Institute of Technology and Mark Del Giorno, General Dynamics Robotic Systems vice president, Borenstein participated in a week-long Qualification, Inspection and Demonstration (QID) event. The ITET met with each of the 22 teams, conducted interviews about its robotics technology and inspected all vehicles. At the conclusion of the QID event, 15 teams had successfully demonstrated that their robots' prescribed safety features were working and had performed the obstacle avoidance and waypoint finding functions properly, explained Borenstein. Those 15 were selected to proceed to the rugged desert course, complete with challenging switchbacks and narrow roads. Participants did not learn the exact route until just two hours before the event when they were given a CD with the latitude and longitude of some 2,000 waypoints.

Although no robotic vehicle completed the full course or claimed the $1 million prize, "Some bots made it an astonishing seven miles," said Borenstein. DARPA will hold its second Challenge in 2005, and Borenstein hopes to participate again. "Where else can you go and check out everyone's technology without being thrown off the premises?" he joked. "To me, as a roboticist, it's the ultimate playground."

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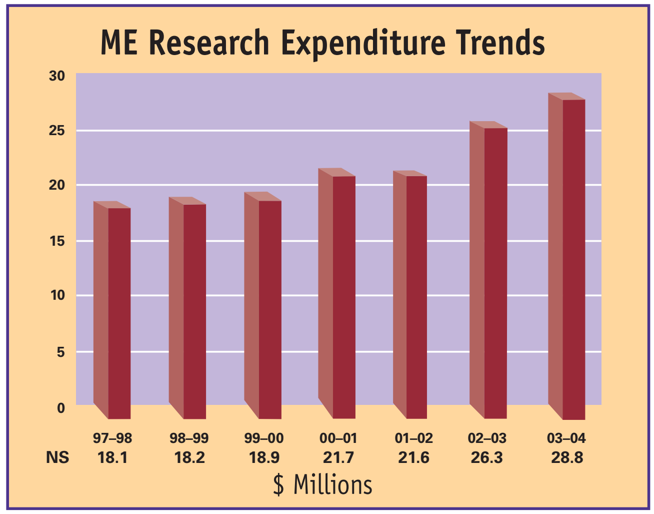
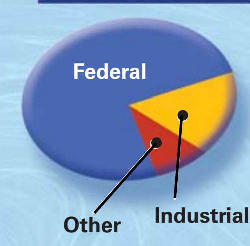


ME Research Expenditures



Distribution by Source
May 1, 2003–April 30, 2004

	%	$
Federal	74.45	21,463,956
Industrial	17.58	5,068,469
Other	7.97	2,296,544
	100.00%	28,828,969

ME Departmental Expenditures

Distribution by Source*
May 1, 2003–April 30, 2004

	%	$
Academic Support[1]	5.25	2,017,986
Instructional[2]	18.00	6,914,845
Scholarships and Fellowships	1.68	643,883
Research[3]	75.06	28,828,969
	100.00%	38,405,682

1 Funds used to support the academic mission of the department (infrastructure)
2 Funds used to support teaching and classroom activities
3 Funds from external (federal and industrial) and internal sources used for research support and generation

Undergraduate Courses Receive High Marks

At the close of each semester, students are asked to complete an evaluation for each class taken. Two questions, designed to measure how students perceive the course and its delivery are especially important indicators to faculty and administrators, explained Professor Gregory Hulbert, undergraduate program director. Those questions are: "Overall this is an excellent course" and "Overall the instructor was an excellent teacher." Students are asked to rate those statements on a five-point Likert scale, with 1 indicating that they strongly disagree and 5 indicating that they strongly agree.

ME undergraduate programs team member (left to right) Professor and Undergraduate Program Director Greg Hulbert; student services staff members Susanne Davis and Sue Gow; and graduate student Tony Vittorini, who serves as the student peer advisor.

This year the three-year rolling averages for all undergraduate required courses have exceeded 3 on both questions. There were also "new highs in quite a number of courses on the evaluations," said Hulbert.

The high marks are no surprise given the "very deliberate effort on the part of faculty to continually improve their courses. Our faculty are dedicated to delivery better and better products, and that's being reflected in the evaluations," added Hulbert.

A number of departmental initiatives support faculty teaching efforts, including Teaching Incentive Fund Awards for faculty earning high evaluation scores for required courses as well as technical electives. This year, seven faculty earned awards. Additionally, all scores are distributed throughout the department so faculty may compare their own scores to the maximum and averages across courses.

An appealing selection of elective courses may also play a role in the good evaluations faculty receive from students. Four new courses — open to both graduates and undergraduates — were introduced this year, which is a higher number than in past years. According to Hulbert, "There's been a lot of energy around establishing new offerings that provide undergraduates with opportunities in developing areas of ME. It's a way of offering a broader perspective beyond the traditional issues."

New courses introduced during the 2003-04 year include:

- **Biomechanics for Engineering Students (ME 406):** Taught by Associate Professor Edgar Meyhöfer, this course teaches fundamental properties of biological systems followed by a quantitative, mechanical analysis.
- **Electronic Circuits Laboratory (ME 453):** This self-paced course was developed by Assistant Professor Robert Dennis. Students design, build and test useful electronic circuits to understand how they function and to improve their circuit design skills.
- **Global Product Development (ME 581/MFG 574):** This project-based course, taught by Professor Debasish Dutta, teaches students how to work in global teams, comprised of students from three universities, to develop a product for the global market.
- **Ecological Sustainability in Design and Manufacturing (ME 589):** Co-developed and taught by Assistant Professor Steven Skerlos in ME and Kim Hayes, associate professor of environmental engineering, this course provides students with a scientific basis for understanding and reducing the environmental impact of engineering design and manufacturing decisions.

ME Teaching Incentive Fund Awardees
(with the course for which they received the award)

Bob Dennis	ME450, Fall 2002
Wayne Jones*	ME382, Winter2003
Jon Luntz	ME450, Winter2003
Anna Stefanopoulou	ME360, Fall 2002
Dawn Tilbury	ME360, Winter2003
Alan Wineman	ME450, Fall 2002
Margaret Wooldridge	ME230, Fall 2002

** Professor, Materials Science & Engineering*

Undergraduate Program Ranked #2

teaching & outreach

NSF Program Builds Tribal College Partnerships

This fall, students from three Michigan tribal colleges will begin an education in engineering thanks to a novel program developed by staff in the National Science Foundation Engineering Research Center for Reconfigurable Manufacturing Systems (ERC-RMS).

Students taking a tour of the ERC-RMS learn about the Portable Manufacturing System. Participants in the NSF-funded partnership with tribal colleges will learn about this system and later introduce it to middle and high school students.

Students from Saginaw Chippewa Tribal College in Mount Pleasant, Bay Mills Community College in Brimley and Keweenaw Bay Ojibwa Community College in Baraga will participate in the program, designed to address the shortage of underrepresented minorities in the sciences, technology, engineering and mathematics fields. Ultimately the goal is to contribute to the development of a diverse, well-prepared workforce of scientists and engineers, according to ERC-RMS Education Coordinator Lenea Howe, who has run recruitment programs for minority students in the past and developed the concept for this particular partnership.

To start, students will be introduced to basic engineering and technology principles, skills and terminology on their home campuses through lectures by U-M graduate students and faculty. Students will participate in the Portable Manufacturing System project, an innovative, hands-on program that demonstrates the concepts of manufacturing engineering to secondary school students. They'll learn computer-aided design and manufacturing, basic computer programming skills and will be introduced to robotics, milling machines and drill presses. Using a computer, they'll design a simple project, and via a web cam at the ERC-RMS test bed, they'll watch their design become reality as it is manufactured.

Students will then visit Ann Arbor, where they'll shadow U-M students visiting middle and high school classrooms to learn teaching techniques for the Portable Manufacturing System. During the winter term, they will travel to middle and high schools in their own area to introduce the project.

During the summer of 2005, students will take an intensive four-week course in Ann Arbor designed to bolster English, math and science skills, in preparation for application to the College of Engineering's undergraduate program in mechanical or industrial engineering.

Accepted students will complete two years of coursework at U-M toward a BS in engineering, according to Howe. During each step of the program, ERC-RMS staff, other students and faculty will serve as mentors. The Minority Engineering Programs Office, the Women in Engineering office, Office of Multicultural Student Affairs and student groups such as Underrepresented Minority Mechanical Engineers and the American Indian Science and Engineering Society will also provide support.

Students will spend their summers in the Research Experience for Undergraduates program where they will work on ERC-RMS projects, sharpen oral and written communication skills and prepare for graduate study.

The NSF-funded program covers the students' housing, conference travel, laptops and software, tutoring and stipends. Upon graduation and acceptance into a College of Engineering graduate program, students may receive full funding through the PhD level.

Howe and her colleagues in the ERC-RMS are thrilled about the new program and the opportunities it affords.

"It really is a win-win. We have very few Native American students in engineering. We need to build that. The success of this program, the real success, will be to see those kids with degrees. And not just these ten but all of the others that follow after seeing what the first few do."

Reaching Out

teaching & outreach

Undergraduate Research Opportunities Program

The Undergraduate Research Opportunities Program (UROP) began 15 years ago as one of several initiatives to improve the retention and academic achievement of underrepresented students on the U-M campus. The program now includes both minority and majority students but maintains its original emphasis on underrepresented minority students and has an emerging focus on women in the sciences.

In its first year, 14 first- and second-year students were paired with faculty in order to engage them in current research projects. Now more than 900 students and 600 faculty researchers are involved in partnerships throughout U-M.

This year Assistant Research Scientist Keith Baar mentored three UROP students. Students spent between 12 and 15 hours each week working in his lab. When they began, Baar was able to "really sit down and go into why we're doing these experiments and what we're looking for. I think that was helpful for them — they're better able to respond to the small questions and issues that come up, and they're invested in the projects."

Two of the three students are working on research into the effect of amino acids on muscle tissue growth, and one is working on the engineering of tendon tissue (see story on page 14).

Students are so invested and involved in all areas of the lab's work that "they're able to continue research while I'm away, so work doesn't have to stop when I need to go out of town," said Baar.

"They take a lot of pride in what they're doing, and I have no problem giving them a lot of responsibility. This was the first year I've mentored UROP students," said Baar, "and I'd definitely do it again."

Engineers Without Borders

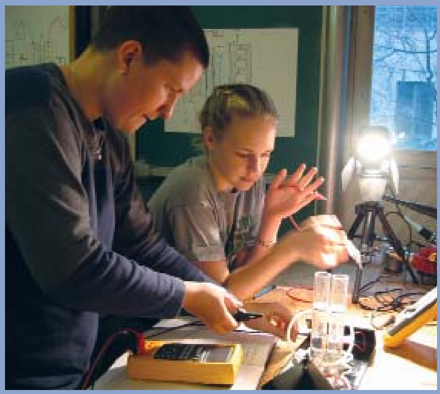
For an organization barely one year old, the University of Michigan chapter of Engineers Without Borders (EWB) has already accomplished quite a bit. More than 30 members have joined; the group has established an executive committee as well as subcommittees in the areas of field studies, technology research and education; and a technical study to evaluate prospective water purification methods in Birkali, India.

The technical solutions the group is considering are made from items such as buckets and soda bottles and pottery, "pretty low-tech," explained Assistant Professor Steve Skerlos, faculty advisor to EWB. That's by design. "Unfortunately there's a history and legacy of developed countries designing and installing fancy technological systems in developing countries that don't have the money to maintain them or the know-how to fix them. When they break, you're back to where you started and they become monuments to inappropriate design. We're looking for more sustainable solutions."

The chapter is currently looking into setting up a field office in Latin America, complimenting the presence of other U-M humanitarian efforts in the area. "The best way to do technology transfer is to get local," said Skerlos. EWB has also developed a Certificate Program in Socially Responsible Engineering, which will be offered for the first time this fall. "Our goal is to get students talking about the environment, development, ethics and sustainable technology, and our hope is that some of these topics will make their way into mainstream CoE courses," said Skerlos. It's already starting to happen. The senior design class, ME 450, has undertaken two EWB projects — a solar-powered cooker and a two-bucket water purification system that is currently being tested for field use.

Skerlos recently won the Outstanding Student Advisor Award from the College of Engineering, but he credits chapter co-presidents Andres Clarens and Tim Towey with sparking the chapter's formation and sustaining enthusiasm.

"EWB and U-M are mutually compatible," said Skerlos. "We have a mix of energetic students that are unusually proficient in organizing and managing projects. They're independent, responsible and willing to take charge. Combine a humanitarian interest in the environment with students who have this sort of energy, and suddenly you've got something that's taking off."



HYDROGEN BUBBLES TEACH VALUABLE LESSONS

Merri Schmitt, an eighth-grader from Indiana, spent her Thanksgiving break counting hydrogen bubbles in the lab of Associate Professor Anna Stefanopoulou. The exercise was part of an experiment Schmitt designed to model hydrogen production as a function of sun intensity from a toy solar electrolyser in order to learn more about reversible fuel cells.

Using water, a light source, a reversible fuel cell model, timer, volt-meter, current sensor and measuring tape, Schmitt learned that each time she moved the light source closer to the solar panel, more hydrogen bubbles were produced.

Making an IMPACT

Prospective students participating in IMPACT weekend have some fun on the field at the U-M football stadium. Later, several participants decided to attend ME, including Kagya Amoako, Rapheal Bollar, Jessica Garrett, William Harrison, Danese Joiner, Serge Li Hoi Foo-Gregory, Scott Norby-Cedillo and Violeta Tayeh.

This year, for the fourth in a row, the IMPACT program has been doing what its name suggests: making an impact on talented minority students traditionally underrepresented in engineering, math and the sciences. In March, 12 students who had applied to the ME department and were accepted came to Ann Arbor to participate in the four-day, all-expenses-paid program, according to Graduate Recruiter Laura Elgas.

Throughout the long weekend, students met formally and informally with current graduate students and toured campus, including the laboratories and facilities they would use if they chose U-M.

"I think seeing the labs really makes them feel like 'Wow, I could be working on this machinery, on this state-of-the-art equipment, that I wouldn't get to use at a lot of other schools,'" said Elgas.

Students had opportunities to meet one-on-one with faculty members in their areas of research interest, too. "It's quite an adventure," said Elgas. "We do a lot of running around to make sure everyone is able to get the most out of their time here." Organized events included panel discussions and Q&A sessions with current students and a welcome dinner and game night, both of which were organized by the Society of Minority Engineers & Scientists – Graduate Students Component, which is "always very involved," said Elgas. "We're so grateful to groups who take time out to do this."

The program is also indebted to the faculty who make time to meet with students, despite hectic summer schedules. According to post-event surveys, meetings with faculty were the most valuable part of the weekend.

Of the dozen students who participated, seven enrolled in the ME PhD program. Their early on-campus experience extended well beyond IMPACT weekend, to their arrival on campus last fall.

"There was a lot of networking among these students. They communicated over the summer and several arranged housing together," Elgas said. "When they arrived on campus, they already knew the ropes."

"When they arrived on campus, they already knew the ropes."

Interactive Teaching Tools

In January, Assistant Professor Hong Im was awarded a grant from the Faculty Development Fund of the University of Michigan Center for Research on Learning and Teaching. The two-year grant will cover development of a computer-assisted interactive course package for the course Computational Fluid Dynamics (CFD) I (ME/AE 523). This graduate course is offered jointly by the mechanical and aerospace engineering departments and consistently enrolls between 30 and 40 students with backgrounds in a variety of engineering and applied mathematics disciplines.

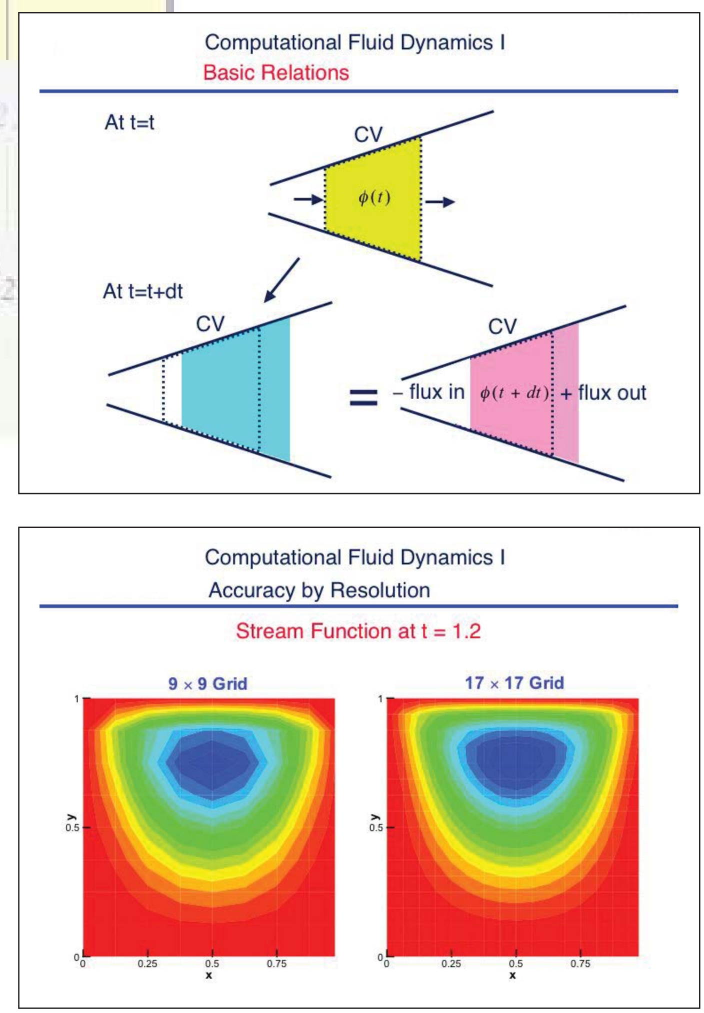
Influenced by his predecessor, Gretar Tryggvason, a former ME faculty member who now teaches at Worcester Polytechnic Institute, Im has been using MS PowerPoint® presentations to deliver his lectures since he began teaching the course in 2001. CFD gives students the foundation for developing computational models in the areas of fluid dynamics, heat transfer and other transport processes. "In engineering applications, computational models are much cheaper, assuming you can trust the results," said Im. "At a fundamental level, you can also unravel — and really look into all the details of — phenomena that are hard to measure. To get to that level, you need to understand the numerical schemes and validate your model."

Since the course relies heavily on understanding equations, grid structures and changes over time, it lends itself well to computerized animation. "These things are just not easy to draw on the blackboard," said Im. The presentations he's been using have drawn extremely positive responses from students. "It really helps them understand all of the key concepts without getting bogged down in the details; they see how the solutions are moving and changing in time."

The grant will allow Im to develop several "subject modules," which will include additional presentations and self-corrective exercises. The modular design is important, he said, considering the wide variety of mathematic and algorithmic principles used in different scientific communities. By combining modules, specific course "paths" can be tailored for different approaches and applications.

The goal of the current project is to develop a set of subject modules for the introductory and intermediate level finite-differencing and finite-volume methods for compressible and incompressible flow solution techniques. After that, specialized modules such as spectral methods or the Lagrangian approach can be added. His vision is ultimately a self-contained, comprehensive package that can be used in traditional courses as well as self-guided tutorials for distance learning programs. Eventually he would like to see the project evolve into a collaborative effort among faculty members university-wide who have specialized approaches to computational modeling.

Currently, Im is working with recent ME graduate Chris Depcik, who is developing the graphical interface, a concept that is "very effective because you can immediately see the results of your code interactively," said Im. The idea, he added, is not to hand students a "black box" of answers. "They still need to come up with their own codes — they have to go through the struggles and agonies to develop detailed code because that's the only way you learn. What I can provide is a tool to help minimize the trial and error. They come up with the subroutines and then use the GUI to see their results. If the code bombs, you can easily detect where the error is. It makes life easier by letting them visualize their results so they can correct the bugs and correct their own code."



Excerpts from Im's CFD 1 lecture notes.

Innovation Improves Graduate Application Process

In the fall of 2002, the ME Graduate Programs staff took a hard look at the department's procedure for processing applicant files.

Despite the fact that most prospective students submit applications online, some information still arrives by mail. Opening mail and collating application files are time-consuming tasks. The entire process can be frustrating for applicants, particularly international students using different postal systems, who don't know whether transcripts, recommendation letters and other requested materials are lost in the mail or sitting on someone's desk.

"Staff members were spending more than 15 hours each week responding to inquiries personally," said Laura Elgas, the office's graduate recruiter. While important, the task of responding to routine inquiries took time away from other activities, like identifying top applicants and getting completed applications to the graduate admissions committee. Some other schools do not respond to inquiries until files are complete, but that only elevates the applicant's anxiety level, she said.

Graduate staff set out to develop an online system that would provide prospective students with up-to-date information about their application status while reducing the number of calls and emails to the office. Presenting a tech-savvy yet user-friendly and welcoming face to prospective students was also a chief objective, according to Elgas. ME Webmaster Chris Africa and Programmer Analyst Asad Habib provided the application and interface design, programming and database development.

The resulting system, named the Graduate Application Tracking System (GATS), was given a trial run in fall 2003 and then put to the real challenge: the January admissions cycle, which sees between 900 and 1,100 applications for fall term admission.

Core members of the GATS project team discuss the interfaces. Seated is web programmer Asad Habib. Standing from left are Graduate Recruiter Laura Elgas and Webmaster Chris Africa.

Hundreds of inquiring emails have been reduced to a couple of dozen per week.

Today, applicants receive via email a link to a personalized web page showing which of their documents have arrived and been processed by the department. As supporting documents are received, staff members log the new arrivals in a database. Except for brief periods when the system is updating, applicants can view their web pages 24 hours per day, seven days per week to discover whether any of the items they've submitted require follow-up, according to Habib.

Hundreds of inquiring emails have been reduced to a couple of dozen per week, and despite the automation, applicants laud the system's friendliness and ease of use. All they need is a web browser and Internet connection.

Applicants have also praised ME for providing a state-of-the-art tool that quells their anxiety about missing documents and keeps the lines of communication open. Applicants who had used similar systems said that GATS was the clearest and most user-friendly.

An additional benefit is the chance for relationship building with applicants. "There's a recruitment opportunity every time you communicate with a prospective student," Elgas explained. "It gives the department, the university, a chance to say, 'Thank you for applying. Please contact us if you have questions.' That kind of communication opens a lot of doors."

GATS affects the whole admissions process, according to Elgas. "When we compile applications faster they get to the review committee faster, which provides the opportunity to select top students before other universities. It gives us a competitive advantage in making a good first impression, and that helps us recruit excellent students."

The system has drawn curious inquiries from College of Engineering administrators as well as information technology staff in other parts of the university. The system is hosted by the Computer Aided Engineering Network, which provides network and lab support, and web hosting services for the engineering community.

"We met our first three goals — to create a system that enhances staff efficiency and demonstrates that our admissions process is tech-savvy, while continuing to reassure applicants that we're on top of things," said Africa. "Our next goal is to make GATS available to other departments in the College of Engineering, so they can reap the same benefits."

SJTU/KAIST Partnerships Mature and Expand

Partnerships with overseas universities provide opportunities for students and faculty alike that extend well beyond technical research. These joint ventures provide the chance for participants to live and study abroad, immersing themselves in different cultures and languages, which prepare them to be conscientious and competitive in today's global economy. The growth of the two collaborative programs below speaks to their importance and to their success.

Shanghai Jiao Tong University, China

"There are a lot of things happening," said Professor Jun Ni, faculty supervisor of the cooperative program with Shanghai Jiao Tong University (SJTU) in China, a primary international partner of the U-M College of Engineering. That may be an understatement. This year 14 undergraduate students from SJTU participated in the program in Ann Arbor; six earned master's degrees; four started PhD programs; and five junior SJTU faculty members were hosted by ME faculty. In Shanghai, eight U-M faculty taught courses to more than 300 undergraduates and 200 master's degree students.

In addition five students from U-M took courses in Shanghai, and 13 undergraduates participated in the Global Intercultural Experience for Undergraduates program, sponsored by the Office of the Provost and Executive Vice President for Academic Affairs and the Vice President for Student Affairs. Professor Yoram Koren also joined the program, which facilitates experiential field study for first- and second-year students. Hosted by SJTU, participating students made plant visits to different types of companies in China, including foreign-owned multinational corporations, state-owned enterprises and a privately owned firm. They conducted research and interviews with company executives about their management strategies in addition to taking Chinese language and culture classes.

"Students not only learned how to run a company in a different country but developed an appreciation for the culture and language of their future competitors," said Ni.

This was the fourth year of the cooperative arrangement between U-M and SJTU, and already both universities are exploring ways to grow it. At U-M, the program may be expanded to include the entire College of Engineering, and the Medical School is also developing a relationship with SJTU. Both universities are at the forefront of U.S.-China exchange programs, said Ni.

"Collaboration is so important. Today's students have to perform in multicultural, multilingual environments," said Ni. "The time to provide that background is while they're receiving their educational training. China is one of the main emerging economies in the world, so it makes sense to start partnerships with a top university."

Korean Advanced Institute of Science and Technology, Korea

The ME department's partnership with the Korean Advanced Institute of Science and Technology began in 2001, supported by the Korean Ministry of Education's Brain Korea 21 initiative to improve graduate-level training in mechanical engineering and several other scientific and technological fields. The original agreement was for a five-year program, which will end with the 2004/2005 academic year.

According to Assistant Professor Hong Im, program coordinator for U-M along with Sang Yong Lee in the KAIST Mechanical Engineering department, the collaboration has been a fruitful one. Representatives from both institutions are working together to define shared goals for the next phase of the program.

To date, more than a dozen students and six faculty members from KAIST have come to U-M. This year, ME Department Chair and Professor Dennis Assanis hosted student Seokhwan Lee and served on the PhD committee of Tong Won Lee, whose dissertation was entitled, "Engine Controllers for the Hydrocarbon Reduction during Cold Start in SI Engine." Im served on the PhD committee for Sang Hun Kang, who recently earned his PhD. His dissertation was entitled, "Fundamental Studies of Combustion Instabilities in Narrow Channels." Two PhD students of KAIST visited U-M this year: Professor Noel Perkins hosted Joonkeol Song from Professor Chong Won Lee's group, and Professor Dennis Assanis and Associate Research Scientist Zoran Filipi hosted Seokhwan Lee from Professor Choongsik Bae's group.

This year the program also hosted its third UM-KAIST Joint Workshop. Bio and nano technologies were the focus of this year's conference, held in Daejeon, Korea. Several U-M faculty and students attended the "very successful" workshop, said Im. The exchange of ideas at the two-day event as well as during the past three years has set the stage for the program's next phase.

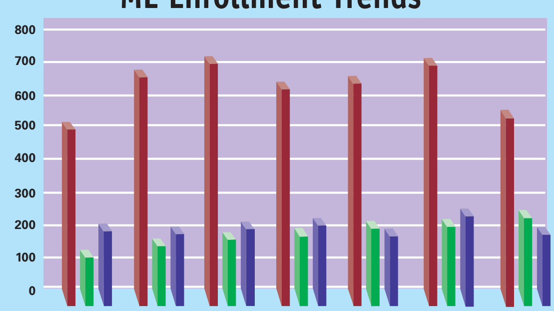
"The program has definitely evolved," said Im. "We've gotten to know what's going on in each others' labs, which will allow us to build more collaborative research projects. There are already some active collaborations going on, but now we can start doing that on a larger scale with participation from a broader group of faculty members."

Today's students have to perform in multicultural, multilingual environments. The time to provide that background is while they're receiving their educational training.

Participants in the third KAIST/GIST-U-M Joint Workshop held May 2-4, 2004.

enrollment & degree trends

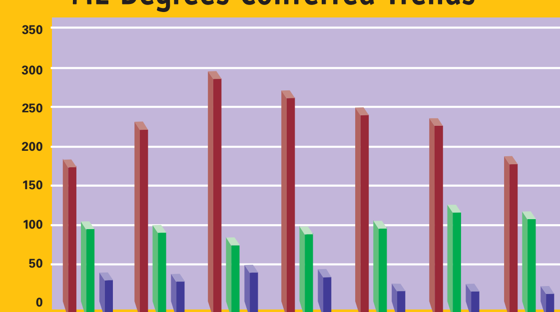
ME Enrollment Trends



	97–98	98–99	99–00	00–01	01–02	02–03	03–04
BSE	506	665	709	639	650	704	560**
MSE	110	150	164	189	208	213	266
PhD	194	184	202	207	186	253	197

*** Based on 3rd week count by U-M Registrar. Does not include all dual/joint students.*

ME Degrees Conferred Trends



	97–98	98–99	99–00	00–01	01–02	02–03	03–04
BSE	180	229	296	265	249	244	209
MSE	102	95	81	93	108	126	122
PhD	35	32	43	39	26	26	22

Four Receive NSF Graduate Fellowships

Four ME students were among 900 students nationwide to receive National Science Foundation Graduate Fellowships in March 2004.

The grants provide three years of support for outstanding students in the early stages of their graduate study leading to research-based master's or doctoral degrees in the fields of science, mathematics, and engineering supported by the NSF. Each fellow receives an annual stipend of $30,000 and a cost-of-education allowance of $10,500, paid to the Fellow's institution in lieu of tuition and fees. At Michigan, Rackham Graduate School will pay the tuition difference and provide health insurance.

The ME NSF Graduate Fellowship recipients this year are doctoral pre-candidates James Allison, Michael Cherry, Adam Hendricks, and Jarod Kelly. All are in their first year as ME graduate students.

"The awards are very prestigious," said ME Student Services Associate Cynthia Quann-White, "The applications are reviewed by disciplinary panels of the applicant's chosen field (scientists, mathematicians and engineers). The panelists judge intellectual merit based on intellectual ability and other accepted requisites for scholarly scientific study."

This year, for the first time, applicants were able to take advantage of a one-day application workshop led by Assistant Professor Katsuo Kurabayashi a month before the application was due. Kurabayashi, who joined the ME faculty in 2000, started the workshop, with the support of Professor Arvind Atreya, the ME Graduate Program Chair, to encourage and support graduate students' applications.

"The key to the successful workshop was to involve a panel of students who had previously received the fellowship," said Kurabayashi. "These students shared how they prepared the fellowship application, with help from their professors and senior students. They even shared some of the mistakes that they made in their first try so that the attendees would not make the same mistakes. These students were truly the main contributors to this workshop.

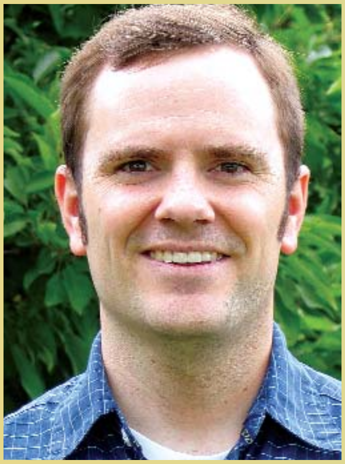
"I feel very proud of the students," said Kurabayashi, "and I have high expectations for them. With the privilege that they enjoy, these students are obligated to perform cutting-edge research and make technological contributions to our society. We need to train them to be competitive researchers and academicians. This will eventually help our research activities become more highly visible."

James Allison received a BS in mechanical engineering (2003) from the University of Utah and an AAS in automotive technology (1998) from Weber State University in Ogden, Utah. Among the other honors he has received, Allison graduated first in the department of Mechanical Engineering at the University of Utah. He is also a member of Tau Beta Pi, Pi Tau Sigma, Phi Kappa Phi, the National Dean's List, and he has been elected to Who's Who Among Students in American Universities and Colleges.

His area of concentration is design optimization. He is currently looking at the optimization of large systems that require decomposition in either a hierarchical or non-hierarchical manner, and at the effect uncertainty has in the optimization of these systems, with a focus on the relationship of these areas to the automotive sector. His advisor is Donald C. Graham Professor of Engineering Panos Y. Papalambros.

"I've always been interested in design," said Allison. "The ability to design some product, mechanical things in particular, the use of engineering tools to predict how it would perform a priori, and then the extension of these tools to develop even better designs, is what first drew me to engineering years ago. I'm especially interested in how mathematical optimization methods can be incorporated into the design process, enabling manufacturers to design the best product to meet their objectives. I'm also interested in how this incorporation can increase the positive impact that well-designed products can have on our society in terms of improved quality of life, improved efficiency in our economy, and reduced energy consumption or impact on the environment.

"I had an opportunity to work with Professor Papalambros in the Optimal Design Laboratory. This lab is researching exactly what I'm interested in, and after surveying many mechanical engineering programs, the University of Michigan had the strongest design optimization program. I had the opportunity to attend MIT or Stanford, but Michigan was simply a better place to research design optimization," said Allison.



Michael Cherry came to ME after receiving his BS in Mechanical Engineering from Brigham Young University in Provo, Utah in April 2003. A native of San Jose, Calif., he also spent two years in Brazil, where he was a missionary for his church.

"While at BYU, I spent two years working with Larry Howell in the Compliant Mechanisms Research lab," said Cherry. "I got involved in research fairly early on, and I thoroughly enjoyed working with the design of mechanical systems that utilize flexibility and elasticity to derive their motion. I looked for other schools that would allow me to continue my pursuits in compliant mechanism research and found the Compliant Systems Design Laboratory.

"When I came to visit Michigan, I had a great impression of the lab, advisors and graduate students working here. It felt right, so I decided that this was the place for me."

Cherry brought with him an impressive array of credentials, including having received the Tau Beta Pi undergraduate scholarship at BYU. In addition to making the BYU Dean's list several times as an undergraduate, he also received an Honorable Mention in the NSF Graduate Research Fellowship competition. This made receiving the fellowship this year all the more gratifying.

Working with his advisor, Professor Sridhar Kota, Cherry intends to continue his specialization in the design of compliant mechanisms because he finds it a better way to design kinematic systems rather than using conventional rigid links and joints.

"Although it is more challenging to design a compliant system, it is more rewarding to me because of the things that can be accomplished," said Cherry. "My area of emphasis within compliant systems is on human augmentation. I believe that through the use of compliant systems, better designs can be achieved to enable people who are healthy to run faster and jump higher, and more importantly, they can aid and possibly restore the motion of people who are disabled."

He plans to focus solely on the lower extremities, primarily the knee and ankle joints through the use of dynamic modeling and analysis of the material mechanics common to compliant mechanism design.

Adam Hendricks earned BS and MS degrees in Mechanical Engineering at Virginia Tech. His master's thesis dealt with developing empirical models of flame dynamics using Tunable Diode Laser Absorption Spectroscopy. The end goal is decreasing harmful emissions of gas turbines through controlling and predicting thermoacoustic instabilities.

Last year, he received an Honorable Mention in the NSF Graduate Fellowship competition, and he has had several conference publications based on his master's work. His advisor is Assistant Professor Bogdan Epureanu.

Hendricks' doctoral work will deal with detecting parametric variations in systems through nonlinear dynamics. Complex systems, such as aeroelastic structures, exhibit chaotic dynamics. In the same way as simple systems tend towards an equilibrium point or cycle, chaotic systems tend towards a strange attractor in phase space. By monitoring changes to the strange attractor, parametric changes to the system can be detected with a high degree of sensitivity. The first application that he will explore is detecting the extent and location of damage to the structure inside an airfoil using the vibratory response.

"I was impressed with the breadth and quality of research in the ME department," said Hendricks. "I also found a professor, Dr. Bogdan Epureanu, whose interests closely matched my own. I like that the university has strong programs in many areas — medicine, business, liberal arts — and that it is situated in a vibrant community."

Jarod Kelly holds a BS in ME from the University of Oklahoma. He has previously been recognized as a National Merit Scholar, and graduated summa cum laude. He was also the group leader for his senior design capstone project, which won first place, and was an Academic All Big 12 as a member of the track team. He recently presented results of his research on porous media combustion at the 23rd Oklahoma ASME/AIAA Symposium. He is being advised by Associate Professor Diann E. Brei.

Kelly is specializing in smart attachment mechanisms. This research examines how smart materials and smart structures can be incorporated into attachment mechanisms to realize improved performance and utility of any particular attachment.

"I find this area interesting because it allows us to step back and examine the fundamental use of an attachment and ask 'Is that enough, or can we get more from this?'" said Kelly. "For example, we could reduce downtime and failure of a machine if we could create a bolt that could tighten itself as vibration started to loosen it. I think this is an exciting opportunity and I look forward to conducting further research in this field."

Smithsonian Calls; ME Undergrad Answers

There are few better ways to spend a summer than working at the Smithsonian Center for Materials Research and Education, according to ME undergraduate student Evan Quasney, who worked at the center for the past two summers.

Quasney's Summer 2004 project was a parametric analysis of the effects of relative humidity on European wooden panel paintings, a large class of paintings which includes renowned pieces of art such as the "Mona Lisa."

His supervisor, Dr. Marion Mecklenburg, "has been pushing the envelope of predictive computer modeling" in the field of art preservation, Quasney said. Mecklenburg learned that Louvre curators had discovered a crack in the back of the "Mona Lisa," so Quasney set out to discover the cause.

Although unable to study the famous painting directly, Quasney was able to develop some general theories about panel paintings by examining others with similar cracking and other similar characteristics.

Because of less-than-ideal storage conditions over the centuries, some panel paintings have deteriorated to the point that they are now in dire need of stabilization. Gesso, a stiff, white "primer" applied to the front of the panel before painting, was long thought to be the cause of warping and cracking. However, Quasney's research this summer quantifiably proved that was not the case. Rather, the installation of battens and cradles, thin strips of a harder wood on the back of the panels thought to reduce warping and cracking, prevented the natural reaction of the panels to changes in relative humidity, which led to cracking.

Quasney's research extended to look at possible prevention methods for future damage. While he did not find a solution to current cracks, he was able to prove through computer modeling that the application of gesso to the back of the panel, would stop warping and cracking by acting as a moisture barrier and as a symmetric constraint opposite the gesso on the front of the panel. Interestingly enough, this same method was recommended four hundred years ago by the great artists in their guides to wooden panel preparation.

Through computer modeling and experimentation in the alternate paintings he studied, Quasney hypothesized that the cracking in the "Mona Lisa" was caused many factors, including the use of battens and cradles. His theory put forward that the painting was hanging on the inside of an exterior wall, the humidity in the air condensed on the wall and dripped down into the back of the panel. This water caused extreme swelling in only part of the wood, and coupled with the high stress already induced by the battens, the wood at the back of the panel began to fail and crack.

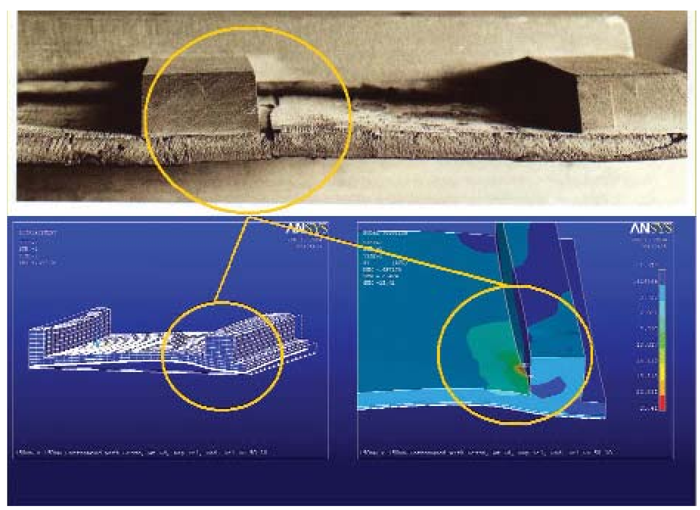
This past summer's work built on the experience he received during his 2003 internship, when his research objective was to determine if a relationship existed between mechanical and chemical properties in wood-based newspapers. A second project, undertaken during "down-time" between testing for the primary assignment, was to determine the true elastic modulus of wood-based newspapers via non-traditional methods.

"The experience was invaluable," said Quasney. "Not only did I build my knowledge base to help ease into the school year, I also gained strong research experience and learned about what mechanical engineering research entails."

Quasney also added that until the first internship, he had had no direct ME training, and the skills and theories he learned are some of the basic cornerstones of mechanical engineering.

Quasney certainly represented ME well, according to a letter to Chair Dennis Assanis from Dr. Charles Tumosa, Senior Research Chemist at the center, who worked with Quasney the first summer.

"If Evan is an example of the education you are providing your students, your program is to be highly commended," he wrote.



Finite Element Analysis of panel paintings can produce very accurate results. A 0.25-inch cottonwood panel with raised cradle was subjected to a 20% reduction in relative humidity. The model produced results that meshed very accurately with crack propagation and deflection-curvature of the panel.

PI TAU SIGMA RECEIVES BEST CHAPTER AWARDS

For the second year in a row the University of Michigan's Pi Rho Chapter of the mechanical engineering honor society Pi Tau Sigma (PTS) won Outstanding Service and Outstanding Chapter awards at the society's national convention. This year the convention was held at Texas Tech University. Six members from Pi Rho attended.

The U-M campus chapter was founded in 1948 and currently has about 40 members. It is one of the largest and most active of the approximately 160 Pi Tau Sigma chapters in the U.S., according to the PTS faculty advisor, Professor Massoud Kaviany. The values of the society include service, leadership, integrity and academic and professional excellence.

"Our chapter has many dedicated officers who help the ME department with academics, provide students with various services and also help the community in many ways," said Kaviany. "We're extremely fortunate — and proud."

In the past year, the chapter has performed numerous service projects. Members cooked dinner for residents at the local Ronald McDonald House and participated in Habitat for Humanity and ProCEED projects. ProCEED, the Program for Community Engagement in Engineering Design, pairs students with community projects that benefit underserved populations, under-resourced projects and the environment.

The chapter is proud of its mutually supportive relationship with the ME department. Pi Rho assists with the ME student-faculty breakfast each semester and tutors students in 100- and 200-level math, physics and ME classes. The president of PTS sits on the ME Student Leadership Board, and every semester a PTS officer updates the ME Student Survival Guide, which is presented to newly-declared ME students. The chapter is well known for its ongoing fundraising activity: grilling and selling brats on the North Campus Diag twice each week.

Members were "elated" to have won both awards for the second year, said Patrick Doll, treasurer, who was quick to acknowledge the entire chapter and its collective enthusiasm as well as the ME department, which plays "a very large role in our success." Among its contributions, the department, along with Student Leadership and Academic Services, provided funding for members to attend the convention. "It shows PTS leadership and the other chapters that we're in fact very committed to what we do."

UNDERGRADUATE AWARDS AND RECOGNITION

Professor and Mrs. William Graebel Top Scholar Award
Ross Mackenzie

Endowments R&B Tool
David Morse
Michael Charlton

Robert M. Caddell Memorial Award
Stephen Rumple

College of Engineering Honors, Awards & Prizes

Distinguished Leadership Award
Antonio Rocco Vittorini

J.A. Bursley Prize
Rahul Sathe

Cooley Writing Prize
Brian Krieger

Andrew A. Kucher Award
Stephen Walton

A.D. Moore Award
Danielle Boyle

Undergraduate Distinguished Achievement Awards

Kevin Donovan

Student Honoree Undergraduate Achievement

Adebisi Adewunmi
Kenya Agee
Elliot Alvarez
Daniel Caratini
Manuel Chavez
Lander Coronado-Garcia
Laura Ellison
James Forehand
Michele Goe
Chad Goldstein
Ian Hanna
Alberto Lopez
Evan Lowe
Vernon Newhouse
Portia Peters
Jonathan Quijano
Vera Simms
Dannielle Sita
Raymond Smith II
Arthur Tyson
Njemile Vinson
Matthew Walker

Student Honorees: Rising Students Achievement

Jermaine Bridges
Cibeles Garcia
Mathew Odigie
Evan Sledge

Graduate Student Awards & Fellowships

ME GRAD SYMPOSIUM

Symposium Awards

Symposium Posters
1st: Karim Hamza
2nd: Jeremy Michalek

Symposium Presentations

Design & Manufacturing:
1st: William Ross Morrow
2nd: Jing Li

Bio-Engineering:
1st:: Alaa Ahmed
2nd: Niranjan Deo

Solid Mechanics & Materials
1st: Kristen Mills
2nd: Wei Li Wang

Fluid Mechanics, Heat Transfer & Combustion:
1st: Alan McGaughey
2nd: Ramanan Sankaran

Dynamics & Controls:
1st: Ardalan Vahidi & Konstantinos Varsos
2nd: Szabolcs Sovenyi

FELLOWSHIPS AWARDED BY ME

Departmental Fellowship
Zachary Dreiner
Rui Li
Jin Liu
Jing Zhou
Qiang Zhou

Rackham Engineering Award
Natasha Chang
Jorge Collazo Delagado
Mark Crawford
Erin MacDonald
Anne Mathias
Jay Mitchell
Pablo Quinones
Nmamdi Sandidge
Miu Yan

Dean's Fellowship
Kiram D'Souza
Kevin James
Jarod Kelly
John Redmond
Jarrod Rivituso
Songtao Tang

Regent's Fellowship
Smitesh Bakrania
Adams Hendricks
Eric Winkel
Xiaowei Zhu

Recruitment Fellowship
JamesAllison
Daniel Benhammou
Michael Cherry
Mark Hoffman

Block Grant Fellowship
Cheng-Shu Kuo

Toyota Fellowship
Chinedu Imediegwu

FELLOWSHIPS AWARDED BY RACKHAM

Predoctoral Fellowship
Chan-Chiao Lin
Alan McGaughey
Katherine Peterson
Sripiya Ramamoorthy
Robert White

FELLOWHSIPS AWARDED BY THE COLLEGE OF ENGINEERING

International Exchange Tuition-Fellowship
Oliver Chaplain
Felix Hildebrand
Jonas Moeck

Ford Fellowship through CEW
Mausumi Syamal

EXTERNAL FELLOWSHIPS

National Science Foundation Fellowship
James Allison
Stephen Cain
Michael Cherry
Adam Hendricks
Jarod Kelly
Beth Miller

Fulbright Scholarship
Luis Izquierdo

The National Consortium for Grad Degreees for Minorities in Engineering & Science Fellowship
(PhD) Nia Harrison
(MS) Olutosin Yusuf

RACKHAM AWARDS

Distinguished Dissertation
Michael Donovan

COLLEGE OF ENGINEERING AWARDS

Distinguished Achievement
Ronald Grover
Alan McGaughey

Distinguished Leadership
Michael Donovan

Elaine Harden Award
Alan McGaughey

UM Outstanding Student Organization Award
Alan McGaughey

MINORITY ENGINEERING PROGRAM OFFICE AWARDS

Master Achievement
Christopher Gold

PhD Achievement
Lesley Berhan

Student Honorees: Master Student Achievement
Christopher Gold
Adrianne Prysock
Jose Rico III
Rocio Saracho
Lara Sherefkin
Deandre Thompson

students

PhD Degrees Conferred

Fall 03

Lesley Berhan
Fused Fibrous Arrays and Mechanics of Carbon Nanotube Sheets
Chair: Ann Marie Sastry

Steve Creighton
Embedding Models of Fine Scale Physics in the Macromechanical Formulation of Solid Mechanics by Variational Multiscale Techniques
Chair: Krishna Garikipati

Christopher Depcik
Modeling Reacting Gases and Aftertreatment Devices for Internal Combustion Engines
Chair: Dennis Assanis

Michael Donovan
Experimental Study of the Role of OH in SiO2 Particle Nucleation In SiH4 Combustion Using UV Absorption Spectroscopy
Chair: Margaret Wooldridge

Chendong Huang
Optimization of Counter Liquid Heat Flow Capillary Artery Evaporator For AMTEC Cell
Chair: William Schultz

Alan Jones
An Experimental Study of the Thermo-Mechanical Response of Elastomers Undergoing Scission and Cross-Linking at High Temperatures
Co-chairs: Alan Wineman, Steve Shaw

Feng Ke
Analysis and Modeling of Chip Ejection in Deep Hole Drilling Processes
Chair: Jun Ni

Morrison Lucas
Understanding and Assessing Logic Control Design Methodologies
Chair: Dawn Tilbury

Ghanem Oweis
An Experimental Investigation Into the Dynamics of Propeller Tip Vortices and the Associated Cavitation Noise
Chair: Steven Ceccio

Winter 04

Gil Abramovich
Part Inspection by Developmental Vision
Chair: Debasish Dutta

Eric Endsley
Modular Finite State Machines for Logic Control: Theory, Verification and Applications to Reconfigurable Manufacturing Systems
Chair: Dawn Tilbury

Mahmoud Hussein
Dynamics of Banded Materials and Structures: Analysis, Design and Computation in Multiple Scales
Co-chairs: Greg Hulbert, Richard Scott

Dong Ying Jiang
Nonlinear Modal Analysis Based on Invariant Manifolds-Application to Rotating Blade Systems
Co-chairs: Christophe Pierre, Steve Shaw

Chang-Ju Kim
Mechanisms of Chip formation and Cutting Dynamics in the Micro-Scale Milling Process
Chair: Jun Ni

Daniel Lim
Laser Processing of Aluminum Alloy 5754 & Silicon Using a High Brightness Diode-Pumped Solid-State Nd: YAG Laser (DPSSL)
Chair: Jyotirmoy Mazumder

Mong-tung Lin
Quantitative Measurements of Liquid Fuel Film and the Piston Top of an Optical-Direct-Injection Engine by Laser-Induced Fluorescence.
Chair: Volker Sick

Mark Palmer
A Non-Linear Hierarchical Model for Stretch-Induced Injury in Skeletal Muscle
Chair: Scott Hollister

Anthony Purtorti Jr.
Simultaneous Measurements of Drop Size and Velocity in Large-Scale Sprinkler Flows Using Particle Tracking and Laser-Induced Fluorescence
Chair: Arvind Atreya

Wendy Sanders
Bubble Drag Reduction in a Flate Plate Boundary Layer at High Reynolds Numbers and Large Scales
Co-chairs: Steven Ceccio, David Dowling

Bruno Vanzieleghem
Combustion Modeling for Gasoline Direct Injection Engines Using Kiva-3V
Co-chairs: Dennis Assanis, Hong Im

Guo Xu
Simulation of Drop Formation and Metal Transfer in Gas Metal Arc Welding
Co-chairs: E Kannaty-Asibu, William Schultz

Pin Zeng
Unsteady Convective Heat Tranfer Molding and Application to Internal Combustion Engines
Chair: Dennis Assanis

faculty & staff

PECASE Recognizes ‘Exceptional Potential’

This spring, Assistant Professor Krishna Garikipati traveled to Washington, D.C., where he attended a White House ceremony to accept the National Science Foundation’s prestigious Presidential Early Career Award for Scientists and Engineers (PECASE).

Garikipati joined 56 other researchers from across the U.S. at the ceremony, presided over by John Marburger III, science advisor to the President and director of the White House Office of Science and Technology. Recipients were recognized for their “exceptional potential for leadership at the frontiers of knowledge,” according to an NSF news release. PECASE is the highest honor bestowed by the U.S. government on early career scientists and engineers.

Garikipati was nominated for the award by the Department of Energy, an agency he’d worked with through Sandia National Laboratories since his arrival at U-M. His work is in the area of theoretical and computational aspects of nonlinear continuum mechanics and the deformation of solid bodies. For the past six years, Garikipati has been interested in problems in physics where mechanics are involved, particularly problems in semiconductors and microelectronic materials — mass transport, heat transport and certain electronic effects.

“They occur together and they influence each other,” he said. “What happens is the physics gets a lot more complex. Many things are going on that before would have been considered separate phenomena, but they affect the material together.”

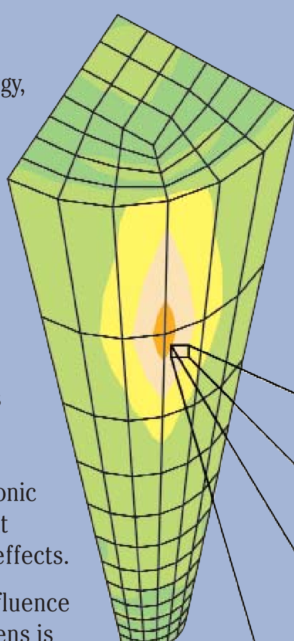
For the past two years, he’s been looking at similar problems in biology, in particular the process of tissue growth and damage. “Complex reactions take place by which mass is created and destroyed. All that happens to biological tissue is strongly influenced by mechanics.

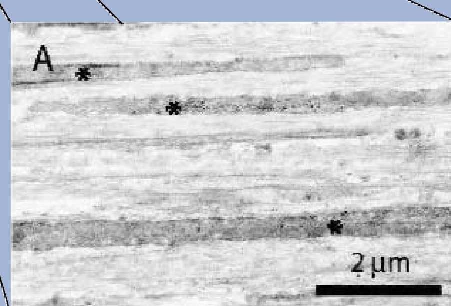
Ten years down the line, they’ll aid surgeons in understanding how scar tissue will develop, how a burn is going to heal.

“Ten years down the line, they’ll aid surgeons in understanding how scar tissue will develop, how a burn is going to heal. The push here is to make this quantitative. It applies to wound healing, to the aging process, to sports and other injuries,” he says of his work in modeling biological growth.

Garikipati has set out to model all these problems mathematically. His work under the PECASE award will allow him to further his research on the deformation of materials at scales of a micrometer and below, where traditional theories of continuous mechanics don’t produce physically-accurate results. The mathematical models he’s working toward will also have a predictive capability, something that’s missing from current work.

Garikipati joined ME in 2000 after earning his master’s degree and PhD from Stanford University, where he also conducted post-doctoral research in the Division of Mechanics and Computation. This year he also earned the Ruth and Joel Spira Outstanding Teaching Award from the University of Michigan’s College of Engineering and the Alexander von Humboldt Foundation Fellowship.





Collagen production contours in a numerical model of a mechanically loaded tendon construct. The inset shows the microstructure of a developing tendon construct with fibroblasts aligned along the loading axis, and surrounded by collagen. This work is joint with Associate Professors Ellen Arruda and Karl Grosh, and graduate students Sarah Calve and Harish Narayanan.

KEVIN PIPE JOINS ME FACULTY

Kevin Pipe recently joined the ME faculty as Assistant Professor.

A Michigan native, Pipe came to the University of Michigan from Massachusetts Institute of Technology, where he completed his undergraduate studies and earned a PhD in electrical engineering in 2003.

Pipe's work focuses on micro and nanoscale thermal physics. At the MIT Research Laboratory of Electronics, he did experimental and theoretical work on heat transfer in electronic and optoelectronic devices such as semiconductor lasers, showing how thermoelectric effects and microscale heat exchange models could be used to design devices that cool themselves internally during operation.

Pipe is currently developing measurement systems in order to image temperature down to the micron and submicron scales. He plans to continue studying heat transfer at small size scales and developing models and experimental methods that enable the operation of next-generation devices and systems. He teaches ME 235, Thermodynamics, and ME 631, Statistical Thermodynamics.

Faculty Promotions

Wenkao Hou, from Research Investigator to Assistant Research Scientist

Marc Perlin, from Associate Professor with tenure to Professor with tenure

ME WELCOMES JOINT FACULTY

Gerard Faeth has been approved for a joint appointment in ME. Faeth is also the Arthur B. Modine Distinguished University Professor of Aerospace Engineering and heads the Gas Dynamics Laboratories in the Aerospace Engineering department.

Faeth's theoretical and experimental research lies in the areas of combustion, heat transfer, fluid dynamics and instrumentation. He is currently working on the physical, optical and reactive properties of soot in flame environments. He has developed measurements to study how soot particles nucleate, grow and oxidize in flames, and is now exploring these problems and processes at the high pressures that are relevant to diesel and aircraft gas turbine engines. He is also investigating the properties and motion of fire plumes, how they carry pollutants and intentionally released toxic substances, and the use of holography to study fuel sprays in power and propulsion applications.

Faeth is a member and national associate of the National Academy of Engineering.

Yogesh Gianchandani recently accepted a joint appointment in ME. He also serves as associate professor in Electrical Engineering and Computer Science and as Director of the College of Engineering Interdisciplinary Professional Degree Program in Integrated Microsystems.

Gianchandani's research focus is device concepts and microfabrication techniques. His current projects include developing microactuators with applications to RF switches, fiberoptic modulators and positioners and developing microprobes and microprobe arrays with embedded sensors for scanning microscopy. His work in the area of microplasmas includes designing radiation sensors as well as high-speed spectral sensors for detecting inorganic heavy metal contaminants in water supplies. Gianchandani is also investigating microfabrication methods for bulk metal, which he has applied to pressure- and flow-sensing cardiac stents.

Gianchandani earned his master's degree in electrical engineering from the University of California, Los Angeles, and his PhD in electrical engineering from the University of Michigan in 1994. He received a National Science Foundation CAREER Award in 2000.

Tim Gordon has been approved for a joint appointment as Professor of Mechanical Engineering. He is also a Research Professor in the Engineering Research Division of the U-M Transportation Research Institute.

Gordon's research centers on dynamics and control, with an emphasis on inductive and nonlinear methods and their applications to automotive engineering. His research at UMTRI includes the development of new driver-vehicle modeling schemes, as well as broader aspects of vehicle control and driver assistance systems. He teaches ME 542, Vehicle Dynamics, and ME 461, Automatic Control.

Gordon previously held the rank of Professor of Automotive Engineering at Loughborough University in Leicestershire, England.

Gordon earned his PhD in Relativistic Field Theory in 1978 from the University of Cambridge.

Ronald Larson recently accepted a joint appointment to ME as professor. He has served as Chemical Engineering department chair and G.G. Brown Professor since 2000. In the fall of 2003, Larson was inducted into the National Academy of Engineering.

The emphasis of Larson's research is the structure and flow properties of complex materials. He is working to detect health markers in saliva and crevicular fluid. He is also investigating the use of small concentrations of polymers to reduce turbulence around ships.

Larson is furthering the understanding of polymer flow properties by developing computer models and experiments to test polymer molecular motion and how that affects stresses and fluid flow. Currently he is using supercomputers to simulate polymer molecular motion, yielding simulations at a level of detail not previously achieved for branched polymers.

Larson earned his master's and doctoral degrees from the University of Minnesota in chemical engineering and was a member of the technical staff at Bell Laboratories before coming to U-M.

ME Faculty Earn NSF CAREER Awards

Assistant Professors Bogdan Epureanu and Wei Lu have both been awarded National Science Foundation CAREER Awards, the Foundation's most prestigious awards for new faculty.

CAREER Awards support the early career development activities of teachers and scholars with the potential for academic leadership. Recipients are selected on the basis of high-impact research and their ability to incorporate it into the educational mission of their home institution. Since 1995, 20 ME faculty members have won CAREER Awards.

Bogdan Epureanu

Epureanu joined the faculty of the University of Michigan in early 2002. His research focuses on the field of nonlinear and chaotic dynamics, with a particular emphasis on the critical areas of structural health monitoring and high-sensitivity damage detection in fluid-structural systems, advanced nonlinear sensing techniques as well as control of nonlinear systems. Epureanu's proposal entitled "Next-Generation High-Sensitivity Damage Detection and Sensing Based on Enhancing Nonlinear Dynamics and Phase Space Pattern Recognition" was one of just four CAREER proposals that were selected by the NSF's Dynamic System Modeling, Sensing and Control division.

Current vibration-based damage detection methods have significant limitations, and exhibit particularly low performance when applied to nonlinear and high-dimensional systems. Epureanu's work "takes a radically different approach," and overcomes these existing challenges through cutting edge research aimed at the development of robust and highly sensitive sensors and nonlinear techniques for identifying the location and level of multiple, simultaneous damages in high-dimensional systems.

Epureanu's new approach has the potential to impact a wide spectrum of applications being the foundation of the next generation of sensors. Each one of these sensors alone will be capable of providing complex and comprehensive information regarding the state of high-dimensional systems. For example, Epureanu investigates space vehicles where the nonlinear vibration of their thermal shielding components during operations, such as reentry into the earth's atmosphere, is used to monitor structural integrity.

In addition to developing new courses in the area of fluid-structure interactions, Epureanu proposed a two-faceted outreach component to his project. First, he will hold hands-on classes about dynamics in general with an introduction to nonlinear phenomena with local high school students at the Ann Arbor Hands-On Museum. Second, Epureanu and his graduate students will develop, in collaboration with museum staff, interactive exhibits that demonstrate nonlinear and chaotic dynamics. Conceptually, the exhibits will demonstrate to museum visitors how the sensitivities of nonlinear and chaotic systems can be exploited for damage detection and sensing, and present in a hands-on approach how tiny perturbations can lead to large changes in the dynamics of such systems.

Epureanu said he is "happy and proud" that the NSF shared his vision of a dramatic increase in sensing capabilities such as sensor fusion, robustness and sensibility by the discovery, characterization and exploitation of fundamental physical phenomena in nonlinear dynamics. Among several other awards he received, in 2004 Epureanu won the Ferdinand P. Beer and E. Russell Johnston, Jr., Outstanding New Mechanics Educator Award from the American Society of Engineering Education and the Junior Achievement Award of the American Academy of Mechanics.

Wei Lu

Lu, who joined the faculty of the University of Michigan in 2001 after earning his PhD at Princeton University, has been investigating a critical challenge in the field of nanofabrication: how to make nanostructures at low-cost and high-throughput. Conventional methods require serial processes that are slow. The promising method Lu is investigating is self-assembly, an intrinsically parallel

Epureanu's work "takes a radically different approach," and overcomes existing challenges through cutting edge research.

faculty & staff

process that has the potential for low-cost, high-yield fabrication. However, self-assembled structures tend toward nonuniformity, and the process lacks size and position control.

Under the five-year award for his proposal entitled, "Programmable Nanoscale Self-Assembly on Solid Surfaces," Lu will continue developing a set of simulation and design tools for

Lu is investigating self-assembly, an intrinsically parallel process that has the potential for low-cost, high-yield fabrication.

the engineering and control of self-assembly that can be applied using diverse materials for patterning nanostructures on solid substrates. He will continue to look at the effects of several forces and interactions, including surface and epitaxial stress, surface electric charges and dipoles, and electric double layers on semi-conductors. By modeling and simulating self-assembly under various conditions and parameters in diverse materials systems, Lu is developing methods to control the process. By manipulating field design through surface pre-patterning, surface modification, anisotropy and temperature, the self-assembly process can be programmed to produce highly uniform nanostructures of desired size and arrangement.

In addition to his research, Lu will develop a new course on nanostructure evolution and self-assembly, which will incorporate material from different disciplines. "In nanotechnology, it's quite normal for research to be multidisciplinary," said Lu. "For example, you need physicists, chemists and materials scientists to work together." The course will be open to senior and graduate students from various engineering programs. Lu will also establish an interactive virtual lab to help students learn and visualize basic concepts and assist advanced users with their research by making self-assembly simulation data accessible. A new set of course modules and supporting tools will also be developed and integrated into the ME department's design and manufacturing sequence.

Lu's overarching vision is to see self-assembly and nanofabrication become a unified scientific discipline. Doing so will ultimately guarantee the continued miniaturization of devices and the development of new devices with applications across scientific disciplines. "Nanostructures are like bricks," explained Lu. "With them you can build all kinds of houses. But first the important thing is, you have to know how to make that brick."

NSF AWARDEES, PAST & PRESENT

CAREER Award Winners

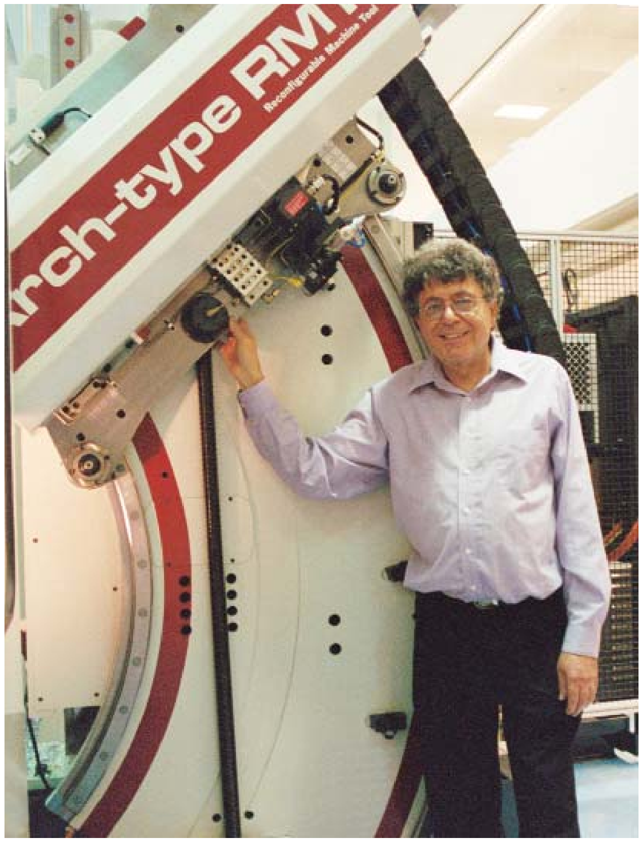
Ellen Arruda	1997
Suman Das	2003
William Endres	1998
Bogdan Epureanu	2004
R. Brent Gillespie	2001
Karl Grosh	1999
S. Jack Hu	1996
Hong Im	2002
Katsuo Kurabayashi	2001
Wei Lu	2004
Jonathan Luntz	2001
Huei Peng	1998
Kazuhiro Saitou	2000
Ann Marie Sastry	1997
Albert Shih	2000
Steven J. Skerlos	2001
Anna Stefanopoulou	1998
Michael Thouless	1995
Dawn M. Tilbury	1999
Margaret Wooldridge	1998

PECASE and Presidential Faculty Fellow Award Winners

Krishna Garikipati	2004
Jun Ni	1994
Ann Marie Sastry	1997
R. Brent Gillespie	2002

Professor Yoram Koren Elected to NAE

"How many of us have the opportunity of transforming a whole field and see the results in our lifetime?" recently asked Steve Director, Robert J. Vlasic Dean of Engineering, to the annual evaluators of the NSF Engineering Research Center for Reconfigurable Manufacturing Systems (ERC-RMS). Since its establishment in 1996, Professor Yoram Koren, the founding ERC-RMS Director, and his colleagues in the center have had a major impact on the design of a new generation of manufacturing systems that are responsive to market fluctuations. In recognition of this accomplishment Professor Yoram Koren has been elected to the National Academy of Engineering (NAE). He was honored for his "contributions to the science, education, and practice of manufacturing through innovations in reconfigurable manufacturing systems, robotics, and manufacturing system control."



Professor Yoram Koren, director of the Engineering Research Center for Reconfigurable Manufacturing Systems at U-M, with the 'Arch-type' reconfigurable machine tool in the NSF ERC/RMS testbed.

Other accomplishments of Professor Koren include designing and demonstrating the world's first adaptive control integrated with computerized controlled milling machine in 1973 (when mini-computers rarely controlled machines), inventing a mechanical snake robot and an inflatable robot in 1990, and leading the team that designed the world's first full-scale reconfigurable machine tool.

"What we proposed to NSF in 1994 as a next-generation, utopian technology of a living, evolving factory is being recognized today as an obvious requirement for industrial competitiveness," says Professor Koren. This recognition has been achieved by developing the RMS principles and technology, and demonstrating them in a factory environment.

Election to the academy is made in recognition of important contributions to engineering theory and practice, including significant contributions to the literature of engineering theory and practice. It is also intended to honor those individuals with significant achievement in the pioneering of new fields of engineering, making major advancements in traditional fields of engineering, or developing/implementing innovative approaches to engineering education.

The contributions of Professor Koren to engineering education are remarkable. In his book "Computer Control of Manufacturing Systems" that was published by McGraw Hill in 1982 he explained the scientific fundamentals of CNC, many of which are based on his own research results. Over ten thousand students learned the scientific aspects of CNC by studying this book. His research accomplishments and this book developed the framework for a more fundamental and scientific approach to the development of CNC systems, thus paving the way for the creation of computer numerical control as both a research field and an education discipline.

Reconfigurable manufacturing systems (RMS), which Professor Koren has been credited with pioneering, form a relatively new research field within manufacturing. At the heart of RMS is the capability to design responsive manufacturing systems for part families, so that they may be easily changed, according to shifting market requirements. These changes are based in system scalability, which includes adjustment of the output volume to the market demand and system/machine functionality: rapid adaptation of the system and its machines to the production of new products.

Professor Koren holds BS and MS degrees in Electrical Engineering and a Ph.D. in Mechanical Engineering from the Technion, Israel Institute of Technology. He has published more than 240 refereed papers. His three award-winning books in the automated manufacturing field are used as textbooks at universities around the world. In addition, he holds 11 U.S. patents in RMS disciplines, robotics, and machine control.

Among his other honors, Professor Koren is a Fellow of both ASME and SME, and has received several national awards, including the "Ennor Manufacturing Technology Award," the top manufacturing award of ASME. He is also a Senior Member of IEEE, and holds the rank of Active Member of CIRP (International Institute for Research in Production Engineering).

Professor Kikuchi Appointed Roger L. McCarthy Professor

Professor Noboru Kikuchi has been appointed the Roger L. McCarthy Professor of Mechanical Engineering. This new professorship was endowed by Roger L. McCarthy (BSE ME '72), chairman of Exponent, Inc., in Menlo Park, California.

Kikuchi's appointment to the McCarthy Professorship recognizes his significant contributions, tireless efforts and quarter-century of service to the ME department and to the field of computational mechanics. He is renown internationally and serves as chair of the Board of Directors for the Japan Association for Nonlinear Computer Aided Engineering, director of Toyota Central R&D Laboratory and associate technical advisor of the Production Division of Toyota Motor Corporation. He is a Fellow of the International Association for Computational Mechanics and has earned numerous awards, including the Henry Russel Award from the University, the Outstanding Teaching Award and Outstanding Research Award from the ME department and the Distinguished Research and Distinguished Service Awards from the College.

Currently Kikuchi is working to establish a robust method for validation and verification of mechanical computer aided engineering (CAE) software for structural components and systems design in order to assure quality of computer simulation. His other research projects include development of a new shell finite element for automotive body structures, especially for NVR study in automotive engineering and development of new computational methods to calculate eigenvalues/eigenvectors for super-large scale problems with more than 10 million degrees of freedom. He is also investigating a new size and shape design optimization method based on the inverse Shur decomposition of a matrix and an image-based CAE method with X-ray CT scanning technology.

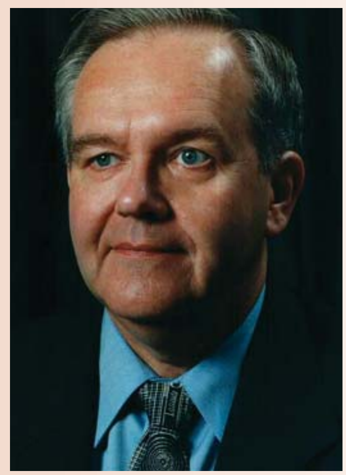
Of his appointment, Kikuchi said he is "honored to know that my activity in academia and industry was recognized for a professorship endowed by Dr. Roger L. McCarthy, since he is so well-known to us for his outstanding achievement. His success in industry and his contributions to the University community are inspiring. I believe this professorship calls for extraordinary activity to build a real bridge between academia and industry, and I'm looking forward to working toward that goal."

McCarthy has been a long-time supporter of the ME department and has served on the External Advisory Board since 1996. He endowed the Roger L. McCarthy professorship to support the teaching and scholarship of a distinguished faculty member in Mechanical Engineering.

McCarthy has a long list of professional accomplishments to his name, the most recent of which is his appointment to the National Academy of Engineering (NAE). The NAE recognized McCarthy for "major contributions to improved vehicle safety and for methods of quantitative assessment of the reliability of complex mechanical systems."

Before becoming chairman of Exponent Inc., McCarthy served as president and chief executive officer of the company, the country's largest engineering firm dedicated primarily to the prevention and analysis of engineering and scientific failures. He was awarded the U.S. Army's Gold Outstanding Civilian Service Medal and has served on the President's Committee on the National Medal of Science. He has also received the ME Alumni Society Merit Award. McCarthy earned a bachelor's degree in philosophy and another in mechanical engineering from U-M in 1972. He earned master's, professional and doctoral degree in mechanical engineering from the Massachusetts Institute of Technology.

Noboru Kikuchi



Roger L. McCarthy

Six Members of ME Earn Excellence in Staff Service Awards

This spring six members of the ME department were honored at the Excellence in Staff Service Awards Ceremony held in Ann Arbor. Leigh McGrath, administrator for the National Science Foundation Engineering Research Center for Reconfigurable Manufacturing Systems (ERC-RMS) earned an individual award. The five-member team in the Academic Services Office (ASO) won a team award. The team includes Susanne Davis, Laura Elgas, Susan Gow, Shanna Jessee and Cynthia Quann-White.

The award program recognizes the significant contributions by staff to the success and prominence of the College of Engineering. This is the second year in a row that a team from ME has won the award and the third consecutive year for an individual from ME.

The ASO serves as the ME department's central academic resource for some 1,200 graduate and undergraduate students during their time in the department — from admissions through graduation. Together the team does everything from recruiting students to helping them complete paperwork and even assisting with personal problems that may arise. According to Professor Greg Hulbert, undergraduate program director, "the benefits to our students and faculty from this team clearly are greater than the sum of their individual job responsibilities."

Susanne Davis is often the first person students see when entering the office. She answers questions pertaining to the undergraduate program, processes course evaluations and schedules rooms for events and exams. Davis has been instrumental with her involvement in the web-based online course pre-registration system. This system was developed with heavy input from Susanne, to ensure priority in registration for select, overpopulated courses in ME. Davis also works with students and faculty to match graders with instructors and ensure students receive their paychecks in a timely manner.

ASO team winners (from left): ASO staff members Susanne Davis, Shanna Jesse and Cynthia Quann-White, ME Chair Professor Dennis Assanis, Administrative Manager Marcy Brighton, and ASO staff Sue Gow and Laura Elgas.

"The benefits to our students and faculty from this team clearly are greater than the sum of their individual job responsibilities."

Also a 'front-line' presence was Shanna Jessee, who has since been promoted within the College. She coordinated the entire admissions process. When not handling 1,000-plus applications, she would offer assistance to the graduate program and, along with Davis, serve as the ASO's resident computer genius.

Twenty-year ASO veteran — and 38-year University veteran — Susan Gow works with nearly 700 undergraduates in any given year, ensuring that they're taking the courses that meet program requirements and offering her support when problems arise. Gow also maintains the ME schedule of course offerings and works to meet the needs of both students and faculty with time and room assignments. In addition, she conveys the many specialized programs offered through ME and the CoE, explaining the nuances and benefits of each.

Laura Elgas oversees graduate recruitment, admissions and enrollment, developing strategies and procedures as well as seeing that new students get acclimated. She and Gow have come to work closely together on two programs that involve the transition from undergraduate to graduate status, the Shanghai JiaoTong University exchange program and Sequential Graduate/Undergraduate Studies. When Gow meets undergraduate students she thinks would be a fit for graduate study, she not only brings them to Elgas' attention but begins conversations with the students as well.

Cynthia Quann-White manages the ASO office and advises graduate students, about 450 at any given point, ensuring that they meet all master's- and PhD-level requirements. She works with Graduate Program Chair Professor Arvind Atreya on

faculty & staff

graduate student issues and petitions, as well as processing fellowship and graduate student instructor selections. She manages and balances fellowship and GSI accounts; administratively prepares payments for student tuition, stipends, and health insurance; and monitors adherence to fellowship stipulations.

Several of the team members also serve on advisory committees, panels, and task forces.

On a regular basis team members work together on behind-the-scenes projects, such as a new student database that Davis and Gow collaborated on. They also pitched in whenever and wherever needed. The group strives to ensure that someone is always available to greet students and faculty as they enter the office. Or if graduate staff members are planning an event, the undergraduate staff will lend a hand.

It's not only a thorough understanding of and ability to clearly communicate policies and procedures that Hulbert most appreciates in the team, but its "helpful and calm demeanor" even under sometimes stressful circumstances.

What's their secret? They credit a shared goal of providing the best service possible to students and sensitivity to each other's needs for their cooperative spirit. They also credit all ME staff, whose efforts help them work efficiently. The combination certainly does the trick. According to Atreya, "The ASO is the heart of our department, and it requires a very dedicated team. We have one! It's because of the ASO staff that we continue to be a model program in many respects."

Individual award winner, NSF ERC/RMS Administrator Leigh McGrath, second from left with NSF ERC/RM Director Professor Yoram Koren, Administrative Manager Marcy Brighton, ME Chair Professor Dennis Assanis.

Leigh McGrath joined the Engineering Research Center for Reconfigurable Manufacturing Systems in 2000. The ERC-RMS is the country's largest manufacturing research center, and when she arrived there she quickly identified the need for improved administrative processes. She implemented a data-gathering and reporting system that exceeded the National Science Foundation's requirements and expectations. As a result the NSF invited her to participate on its consultancy team to help identify best practices and assist other institutions set up new centers.

"It's about making sure people get what they need," says McGrath

On campus, McGrath ensures that the ERC-RMS runs smoothly on a daily basis. Her responsibilities include everything from hiring and developing training plans and budgets to writing reports and proposals, managing grants and coordinating major events. She is known for creative problem solving, exceptional organizational skills and the support and concern she demonstrates to colleagues, staff and students. When a departmental coordinator went on maternity leave, McGrath volunteered to job share despite busily preparing for her own maternity leave. In another instance she helped a member of her staff secure a new position, one that benefited the ERC and positioned the employee to pursue a graduate degree.

McGrath doesn't see her accomplishments as anything out of the ordinary. "It's about making sure people get what they need," she said. In her acceptance remarks, she thanked the entire ERC "family," including staff, faculty, researchers and students and commented that it is "amazing to be rewarded for doing something so enjoyable."

Faculty Honors & Awards

Ellen Arruda
- ME Outstanding Faculty Achievement Award, 2004.

Thomas Asmus
- National Academy of Engineering, 2003.

Arvind Atreya
- College of Engineering Excellence in Service Award, 2003-04.

Keith Baar
- U-M Undergraduate Research Opportunities Program Recognition Award for Outstanding Research Mentorship, 2004.

Diann Brei
- Da Vinci Award, National Multiple Sclerosis Society, Michigan Chapter, and Engineering Society of Detroit, 2003.

Suman Das
- National Science Foundation CAREER Award, 2003.
- Society of Manufacturing Engineers M. Eugene Merchant Outstanding Young Manufacturing Engineer Award, 2004
- Literati Club 2004 Highly Commended Award (with Associate Professor Scott Hollister and research team) for the article "Freeform Fabrication of Nylon-6 Tissue Engineering Scaffolds" *Rapid Prototyping Journal*, Vol. 9, No. 1, 2003.

Dragan Djurdjanovic
- Distinguished Doctoral Thesis Nomination from the ME Department, 2003.

Deba Dutta
- ASME Design Automation Award, 2004.

Bogdan Epureanu
- 2004 Junior Achievement Award of the American Academy of Mechanics.
- Invited by the National Academy of Engineering to participate at the Frontiers of Engineering Symposium, Irvine, CA, 2004.
- American Society for Engineering Education Ferdinand P. Beer and E. Russell Johnston, Jr., Outstanding New Mechanics Educator Award, presented by the ASEE for exceptional contributions to mechanics education, Salt Lake City, 2004.
- National Science Foundation CAREER Award, Washington D.C., 2004.
- American Society of Mechanical Engineers-Pi Tau Sigma Gold Medal Award, Washington D.C., 2003.

Gerard Faeth
- Space Processing Award, American Institute of Aeronautics and Astronautics, 2004.

Krishna Garikipati
- Alexander von Humboldt Foundation Fellowship, 2004.
- Presidential Early Career Award for Scientists and Engineers, 2004.
- Ruth and Joel Spira Teaching Award, 2004.
- PTS Professor of the Term, Winter 2003.

R. Brent Gillespie
- Participant, National Academy of Engineering Frontiers of Engineering program, 2004.

Karl Grosh
- ME Outstanding Faculty Achievement Award, 2004.

Scott Hollister
- Literati Club 2004 Highly Commended Award (with Assistant Professor Suman Das and research team) for the article "Freeform Fabrication of Nylon-6 Tissue Engineering Scaffolds," *Rapid Prototyping Journal*, Vol. 9, No. 1, 2003.
- Henry Russell Award, 2004.

Jack Hu
- Outstanding Overseas Young Scientist, Chinese National Natural Science Foundation, 2004.
- ASME Fellow, 2003.

Gregory Hulbert
- College of Engineering Excellence in Service Award, 2003-04.

Hong Im
- U-M Center for Research on Learning and Teaching, Faculty Development Fund, 2004.

Reuven Katz
- Excellence in Teaching Award, granted by the Technion-Israel Institute of Technology's student association, 2003

Massoud Kaviany
- College of Engineering Education Excellence Award, 2003.

Noboru Kikuchi
- Best Paper Award (with ME Professor Christophe Pierre and Associate Research Scientist Zheng Dong Ma), ASME Design Engineering Division, Vehicle Design Committee, "Function-Oriented Material Design for Next-Generation Ground Vehicles," ASME International Mechanical Engineering Congress and Exposition, Washington, D.C., 2003.

Muammer Koc
- SME M. Eugene Merchant Outstanding Young Manufacturing Engineer Award, 2004.

Yoram Koren
- National Academy of Engineering, 2004.
- Hideo Hanafusa Outstanding Investigator Award, given at the Japan-USA Symposium on Flexible Automation in Denver, 2004.

Sridhar Kota
- American Institute of Aeronautics and Astronautics Best Paper Award (one of two best papers of the year 2003).
- ASME Machine Design Award, 2004.

Wei Lu
- National Science Foundation CAREER Award, 2004.

Zheng-Dong Ma
- Certificate of Recognition from SAE for organizing various symposiums, 2003 and 2004.
- Listed in the Who's Who in America, 57th and 58th editions, 2003, 2004.
- Best Paper Award (with Professors Christophe Pierre and Noboru Kikuchi), ASME Design Engineering Division, Vehicle Design Committee, "Function-Oriented Material Design for Next-Generation Ground Vehicles," ASME International Mechanical Engineering Congress and Exposition, Washington, D.C., 2003.

Jun Ni
- Silver Medal, awarded by Shanghai Municipal Government for Outstanding Contribution by Overseas Scientist, 2003.
- American Society of Mechanical Engineering Fellow, 2004.

Panos Papalambros

- International Institute of Electrical and Electronics Engineers Best Paper in Electromagnetic Compatibility Symposium (with E.S. Siah, J. Volakis, T. Ozdemir, T., and R. W. Wiese), 2003.
- Society of Automotive Engineers Fellow, 2003.

Noel Perkins

- PTS Professor of the Term, 2003.

Christophe Pierre

- Best Paper Award (with Associate Research Scientist Zheng-Dong Ma and Professor Noboru Kikuchi), ASME Design Engineering Division, Vehicle Design Committee, "Function-Oriented Material Design for Next-Generation Ground Vehicles," ASME Congress and Exposition, Washington, D.C., 2003.
- N.O. Mykelstad Award, ASME Design Division, 2003.

Kazuhiro Saitou

- Marquis Who's Who in America, 2002-03.
- Who's Who in Computational Science and Engineering, 2003.
- Best Paper Award (with B. Lee) for junior contributions, "Three-dimensional Assembly Synthesis for Robust Dimensional Integrity Based on Screw Theory," Fifth International Symposium on Tools and Methods of Competitive Engineering, Lausanne, Switzerland, 2004.

Bill Schultz

- Faculty Advisor of Year, ASME, 2004.
- Ginsberg Center Community Service & Social Action's Outstanding Faculty Member, 2004.
- University of Michigan Distinguished Faculty Governance Award, 2004.

Albert Shih

- Society of Automotive Engineers Ralph R Teetor Educational Award, 2004.

Steve Skerlos

- College of Engineering Outstanding Student Group Advisor for Engineers Without Borders, 2004.
- Gilbert Whitaker Grant Award for the Improvement of Teaching, 2003-04.

Anna Stefanopoulou

- Best Paper Award (with Sharon Liu from General Motors Co.) International Institute of Electrical and Electronics Engineers Transaction Control System Technology, "Effects of Control Structure on Performance for an Automotive Powertrain with Continuously Variable Transmission," 2003.

Michael Thouless

- College of Engineering David E. Liddle Research Excellence Award, 2004.

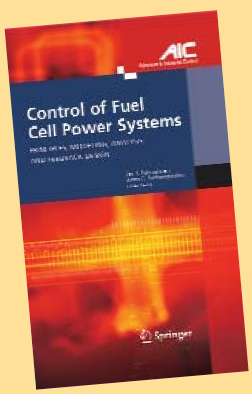
Dawn Tilbury

- ASME Dynamic Systems and Control Division, Dynamics and Controls Division Education Award, 2003.

Margaret Wooldridge

- College of Engineering Education Excellence Award, 2003-04.

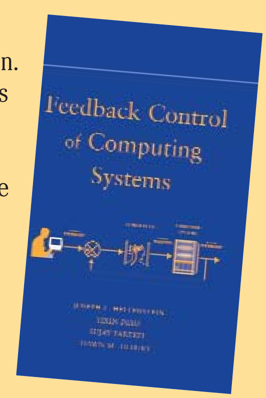
OFF THE PRESSES



Control of Fuel Cell Power Systems: Principles, Modeling, Analysis and Feedback Design by Jay T. Pukrushpan, **Anna G. Stefanopoulou** and **Huei Peng** (Springer, 2004).

Intended primarily for engineers, researchers, and students with basic control knowledge interested in the fuel cell technology, Control of Fuel Cell Power Systems offers readers an overview of the physical principles, main control objectives, and challenges in the automation of fuel cell systems. Detailed control and estimation methodologies are presented based on system-level models with realistic actuator and sensor dynamics. Specific numerical examples are offered for precise control of reactant flow, hydrogen generation, stack temperature, and membrane humidity. Multi-objective controllers that allow modular software development and calibration procedures for tuning in industrial settings are demonstrated in case studies of automotive and stationary power generation.

Feedback Control of Computing Systems by Joseph Hellerstein, Yixin Diao, Sujay Parekh and **Dawn Tilbury** (John Wiley & Sons, Inc., 2004).



Intended for researchers and computer scientists engaged in the analysis and design of computing systems, this book provides the essentials of control theory to address the dynamics of resource management, especially changes in workloads that can lead to service degradation and failure, and configuration. Through numerous examples the authors demonstrate how control theoretic techniques can be applied to computer systems, and they provide insight into the remaining challenges. Control theories are made accessible to readers through the authors' use of modeling that draws heavily on queuing systems and their dynamics as opposed to Newton's laws and through a focus on discrete time systems instead of continuous time systems, which traditional control books tend to use.

Roger McCarthy Elected to NAE

Roger L. McCarthy

The National Academy of Engineering (NAE) has announced the election of 76 new members and 11 foreign associates, including ME alumnus Roger L. McCarthy, chairman of the board, Exponent Inc. and Exponent Failure Analysis Associates Inc., Menlo Park, California, and member of the ME External Advisory Board.

He joins ME Professor Yoram Koren (2004) and fellow EAB members Ward Winer (1998) and Marshall Jones (2001) in having received this prestigious honor (see related story on page 42).

In making the announcement of this honor, the NAE recognized McCarthy for "major contributions to improved vehicle safety and for methods of quantitative assessment of the reliability of complex mechanical systems." This recognition is quite significant, as the NAE is the portal for all engineering activities at the National Academies, including NAE, the National Academy of Sciences, the Institute of Medicine, and the National Research Council. The NAE's mission is "to promote the technological welfare of the nation by marshaling the knowledge and insights of eminent members of the engineering profession."

McCarthy, who was formally inducted in October, has been a longtime supporter of ME. In addition to his active involvement in the EAB's activities since 1996, he has endowed The Roger L. McCarthy professorship to support the teaching and scholarship of a distinguished faculty member in Mechanical Engineering (see related story on page 43).

After receiving a BA in Philosophy and a BSE ME in Mechanical Engineering from the University of Michigan in 1972, he received an MS in Mechanical Engineering, the professional degree of Mechanical Engineering (MechE), and a PhD in Mechanical Engineering from MIT.

As chairman of Exponent Inc. and Exponent Failure Analysis Associates Inc., Menlo Park, California, he oversees the operation of the largest engineering firm in the nation dedicated primarily to the analysis and prevention of scientific or engineering failures.

"My area is mechanical design," said McCarthy, "and I have been in the forefront of using large scale accident and incident databases for design assessment. I have assembled the largest accident and incident data collection in the world (I believe) at Exponent to facilitate this work."

The NAE honor has had had a profound effect on him both personally and professionally.
He noted that he has received more congratulations from friends and colleagues on his election to NAE than on any other event in his professional life.

"On a personal level, it almost makes my career complete," he said.

McCarthy partially credits his ME education for his success. Vehicle safety and the methods he developed for assessing vehicle design were "clearly the result of my Michigan training," he said. "I learned zip about vehicles at MIT. Obviously MIT was important in my training in quantitative methods, but without the Michigan's training, I would have been in some completely different field."

His involvement with the EAB has also been particularly beneficial. "I walk away from every meeting having learned a lot more from you than you've learned from me. These meetings are incredibly valuable survey seminars on current research."

His most recent honors include the U.S. Army's Gold Outstanding Civilian Service Medal in 1998 and the Department of Mechanical Engineering Alumni Society Merit Award for 1994-95. He has served as a member of the ASME's Board of Safety Codes and Standards and on the President's Committee on the National Medal of Science.

"On a personal level, it almost makes my career complete."

Marshall Jones wins Alumni Society Merit Award

As a distinguished scientist, international authority in the field of fiber-optic laser beam technology and a man generous with his time, Dr. Marshall Jones has garnered much recognition in the course of his career, including this most recent honor: the 2004 Mechanical Engineering Alumni Society Merit Award.

"I couldn't believe what I was hearing," said Jones, referring to the moment when the award was announced at a meeting of the ME External Advisory Board, upon which Jones has served since 2001. "There have been some very accomplished ME graduates selected in the past, and I never thought that I would be one of them. It makes my selection even more special."

Jones graduated from the University of Michigan with a bachelor's degree in Mechanical Engineering in 1965. He went on to earn a doctoral degree in mechanical engineering from the University of Massachusetts in 1974. He joined the GE Global Research Center that same year, where he currently serves as senior research engineer and project leader in laser technology. His research focus has been on laser material processing concerning metal forming and thermal management of laser beam-material interaction; his current work is in the area of laser-fiber optic integration for factory automation and hot-wire laser processing including welding and cladding. He has received nearly 50 patents in the United States alone.

Jones has also taught engineering and mathematics as an adjunct professor at Schenectady County Community College since 1975 and in the physics department at the State University of New York, Albany, since 1990. He's actively involved in several local nonprofit organizations and mentors young people both locally and abroad. He's the subject of a self-published children's book, *Never Give Up: The Marshall Jones Story*, which he hopes will encourage underrepresented youth to pursue their dreams.

Just a few of his other, numerous, honors include the National Society of Black Engineers Pioneer of the Year Golden Torch Award and the GE African American Forum's Icon Award for Engineering and Research, both bestowed in 1999. The following year, he received the Black Engineer of the Year Award for Outstanding Alumnus Achievement from the Career Communications Group. In 2001 he was granted the Alumnus of the Year Award from the College of Engineering at the University of Massachusetts. He was named 2002 Coolidge Fellow, the top technical award at GE's Global Research Center which provides six months' leave for recipients to pursue their research interests. Jones will be spending half of his time at U-M. "I could go anywhere in the world, and where do I choose to spend part of my time? Back at U of M. That says something, doesn't it?"

Jones is also a fellow of the American Society of Mechanical Engineering and the Laser Institute of America and a member of Phi Theta Kappa. He became a member of the National Academy of Engineering in 2001.

Dr. Marshall Jones

When asked about the accomplishment of which he's most proud, Jones responds that "one must realize whatever accomplishments I've achieved have been the result of much help from many different individuals. I am truly proud of all of my accomplishments. I can only hope that some of the youth I come in contact with will also believe that they can do some of the things I've done, because I was once just like them. I do attribute much of my success and accomplishments to the great education I received in the ME Department at U-M."

"There have been some very accomplished ME graduates selected in the past, and I never thought that I would be one of them. It makes my selection even more special."

OZDOGANLAR NAMED TO CARNEGIE MELLON ME FACULTY

O. Burak Ozdoganlar (PhD ’99) has been appointed as an assistant professor on the faculty of Carnegie Mellon University Department of Mechanical Engineering effective January 2004. His area of concentration is micro/meso-scale manufacturing and modeling, simulation and experimentation of MEMS/microsystems.

Ozdoganlar came to Michigan for the best of reasons: “It was academically more competitive than Ohio State University, where I got my MS degree. I could have stayed there for my PhD, but decided to come to Michigan. GO BLUE!”

He proved that he was up to the competition by receiving the student of the year award from the NSF Engineering Research Center for Reconfigurable Manufacturing Systems, where he was the president of the Student Leadership Council. He also received a first year departmental fellowship.

His teaching responsibilities at Carnegie Mellon will include the senior-level Advanced Manufacturing course and the junior-level Dynamic Systems and Control. While at ME, he was a teaching assistant for several courses

Ozdoganlar credits his initial experiences at ME with inspiring him to pursue a concentration in manufacturing. He also credits several faculty for their assistance, including his advisor, Professor William Endres, adding that Professor Yoram Koren was really supportive. “My financial support, other than the first year when I had a departmental fellowship, came from ERC/RMS,” said Ozdoganlar. “Another person who helped me significantly initially was Associate Professor Arthur Kuo, as did Professor Noel Perkins, who offered me his assistance whenever I needed it, and Prof. Jun Ni who participated in my dissertation committee.”

Deciding to join the faculty at Carnegie Mellon was a fairly easy decision. “Carnegie Mellon University is a great place to work, one of the top research universities in the country.”

In addition to his doctorate, Ozdoganlar also holds a BS from Istanbul Technical University, Turkey, and two MS degrees from Ohio State University. He also completed post-doctoral work at the University of Illinois at Urbana-Champaign. He was also a senior member of the technical staff at Sandia National Labs in Albuquerque, New Mexico.

ME GRAD JOINS CAL POLY FACULTY

George Delagrammatikas

George J. Delagrammatikas was appointed as an Assistant Professor of Mechanical Engineering at California Polytechnic State University in San Luis Obispo, California, in September 2003.

Among his responsibilities are teaching a junior-level class in Heat Transfer; a senior-level class in Hybrid Electric Vehicle Design; and Internal Combustion Engine Design classes for seniors and graduate students. He is also the first Donald E. Bently Professor in advanced energy systems, a position which allows him to further develop his skills as a researcher. In addition, he advises the FutureTruck and Solar Car Teams.

Delagrammatikas, who earned an MS ME and a PhD from U-M, carved an exceptional resume in a relatively short time. After receiving his doctorate, he was actively involved in developing a neural network methodology for the optimal design of turbocharged diesel engines. He was also part of a team that investigated surrogate modeling methods for automotive applications.

Delagrammatikas was a program assistant for a graduate seminar series in automotive engineering, in which he mentored 65 students in a web-based distance learning network. He adopted further mentoring responsibilities as class advisor in a design optimization course. His contributions to the field were recognized with the Scholar Power 2002 PhD Recognition Award. He is also the co-author of numerous papers.

Prior to coming to ME, he attended MIT, where he received his BS in Mechanical Engineering. While there, he was an undergraduate researcher for the Solar-Electric Vehicle Team, the Sunrayce national champions in 1995.

Delagrammatikas gave full credit to his education at ME for preparing him to reach his goals, mentioning that his adviser, ME Department Chair Professor Dennis Assanis, was particularly helpful. He also credited co-adviser Professor Panos Papalambros, Associate Research Scientists Zoran Filipi and Loucas Louca, and former Associate Research Scientist Nestor Michelena (who died in 2003) for their help.

NSF Summer Institute Fellow

Mahmoud Hussein, a post-doctoral researcher, was one of only 20 professors, post-doctoral scholars and PhD candidates nationwide awarded a National Science Foundation (NSF) Fellowship to attend the Foundation's Summer Institute short course on "Multiscale Modeling and Simulation of Nano Mechanics and Materials."

The week-long course was held at Northwestern University and consisted of lectures, hands-on workshops and laboratory tours. The NSF's objectives in offering the program are to identify and promote important areas of nanotechnology to augment current research and development by universities, industries and government and to train future and practicing engineers, scientists and educators in the emerging areas of nanotechnology, nano-mechanics, and nano-materials. The program also provides valuable networking opportunities for researchers and leaders in the field.

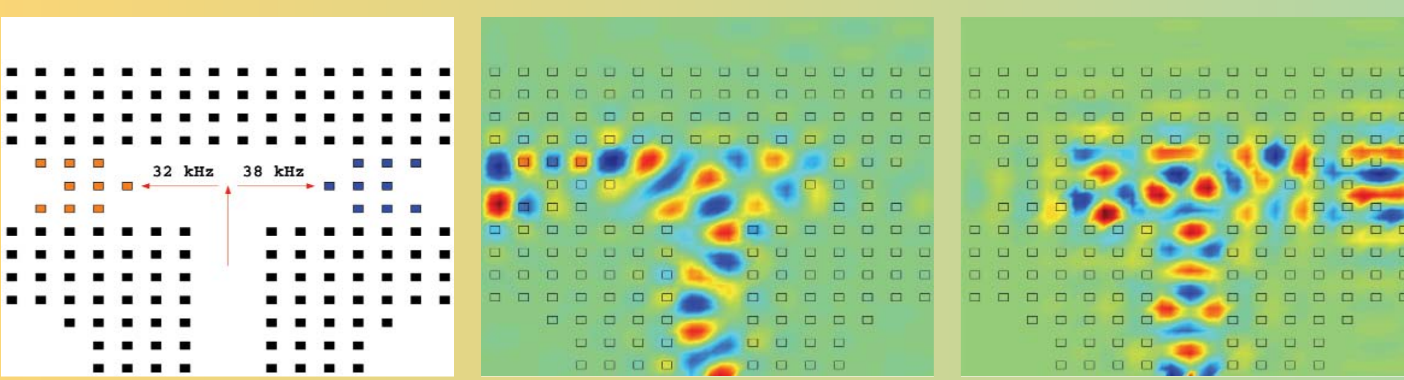
According to Hussein, the course helped researchers with traditional engineering training "realize the remarkable benefits of exploring their problems through a multiscale perspective. This enhances the scope of research because it allows one to exploit knowledge and tools acquired and developed by both the engineering and basic sciences communities."

Hussein's work is in the area of wave propagation in periodic materials and structures. He has been addressing research problems at the continuum level, "but the course helped me see how it could extend to applications at much smaller scales. As much as there are differences across scales, interestingly, there are plenty of similarities, which make it encouraging to engage in collaborative interdisciplinary work."

He said the week-long event was a good opportunity to interact with scientists and engineers from around the country who share a similar interest in and curiosity about nano systems. In addition, course content dovetailed with his dissertation, entitled "Dynamics of Banded Materials and Structures: Analysis, Design and Computation in Multiple Scales" (see accompanying images). Professors Greg Hulbert and Richard Scott served as his thesis advisors.

Mahmoud Hussein

Hussein also earned first prize in the student paper competition at the 40th Annual Meeting of the Society of Engineering Science held in Ann Arbor in October 2003. The paper was titled, "A Multiscale Reduced Order Model for Computing Frequency Spectra of Periodic Materials."



Frequency transducer: through a combination of waveguiding and filtering, this banded structure passively steers 32 kHz to the left and 38 kHz to the right.

EAB Spring meeting

Left to right (standing) are ME External Advisory Board members Marshall Jones, Walt Bryzik, Ward Winer, Ashok L. Nayak, Richard Heglin, Mike Korybalski, Chuck Hutchins, General Paul Kern, Paul D. Nuyen; undergraduate student Laura Stojan; EAB member Roberta Zald, and ME Department Chair Professor Dennis Assanis. Kneeling are undergraduate students Steve Dockstader, Tom Domlovil, and Jeff Lovell; and Bruno Vanzieleghem, Project Manager in the Automotive Research Center. The students participated in the Fall 2004 EAB meeting as representatives of the Mechanical Engineering Student Leader Board.

MEDTRONIC EXECUTIVE JOINS EXTERNAL ADVISORY BOARD

Robert Guezuraga

The ME External Advisory Board (EAB) welcomed a new member in 2003: Robert M. Guezuraga, senior vice president of Medtronic, Inc. (MDT), and president of its Cardiac Surgery Business. Medtronic is the world's largest medical device company, providing solutions for those with chronic heart and vascular disease and neurological and spinal disorders. Guezuraga oversees all business functions relating to heart valves, surgical perfusion products, blood diagnosis and handling and emerging technologies in heart surgery. He joined the company in 1998 and is a member of the Medtronic Executive Committee and the Medtronic Pension Board.

Guezuraga earned a bachelor's degree in mechanical engineering in 1972 from Louisiana State University, is a Registered Professional Engineer and a graduate of General Electric Company's (GE) management program. He began his career with GE and spent 15 years in various business sectors in engineering and manufacturing. He holds several patents in the area of medical technology and serves as trustee for multiple public and private organizations.

Guezuraga joined the EAB after meeting with ME Department Chair and Professor Dennis Assanis about the role of mechanical engineers in the fast-growth area of medical devices. He brings to the EAB his diversity of experience in the medical field and perspective from a high-growth market sector. He's looking forward to "serving on the advisory board and to attracting the best and brightest engineers to my field and to Medtronic."

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