Ph.D. candidates Jeremy Mercuri (Dan Simionescu, adviser) and Chartrisa L. Simpson (Naren Vyavahare, adviser) conduct Hitomorphometric analysis of tissue response to implanted materials.

On the cover: Professor Rhett Smith is a recipent of an NSF CAREER award. Smith's research is directed to developing polymer materials that can conduct electricity.

# IDEaS

INQUIRY, DISCOVERY IN ENGINEERING AND SCIENCE

COLLEGE OF ENGINEERING AND SCIENCE FALL 2009

*in this issue:*



CLEMSON
College of ENGINEERING AND SCIENCE

# From the Dean

In the lobby of the Engineering Innovation Building on the Clemson campus, there is an 1895 Model 16B Graham Escapement Seth Thomas Clock. The timepiece marked the rhythms of the campus for almost a century. In the 1980s, the clock tower was modernized, and the old timepiece was discarded and left to gather dust in the tower belfry. Several years ago a restoration effort brought the clock back to life.

The story of the Clemson clock offers lessons as we address infrastructure concerns here in the U.S. Without attention, bridges, roads and energy systems become outdated, fall into disrepair and ultimately become unusable. The current administration has recognized these needs in formulating policies to deal with the economic downturn. The American Recovery and Reinvestment Act of 2009 (ARRA) provides for domestic spending in education, health care and infrastructure, including the energy sector.

In this edition of *IDEaS* we take a look at some of the research projects that deal with important infrastructure concerns. While these ongoing projects predate the ARRA, I think it is important to note that here at Clemson, we anticipated the need for, and the vitality of, these focus areas.

The nation is facing serious staffing shortages in nuclear science and engineering disciplines. Clemson's nuclear environmental engineering and science graduate program is helping to meet critical work force needs, and we are accomplishing that with environmental awareness and emphasis. This is particularly important now as utilities are seeking licensing extensions for maturing nuclear facilities.

Here at Clemson, we anticipated the need of the focus areas of the ARRA: education, health care and infrastructure, including the energy sector.

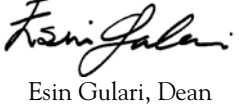
On the consumer side of power generation, two of our mathematical sciences professors are leading a team that's seeking to make smarter electric power networks to boost the nation's economy and ecology. The goal is providing utilities with the tools to ensure uninterrupted service, improve distribution efficiency, save energy and reduce operating costs.

Clemson's research on the durability of concrete infrastructure could mean potential savings of millions, perhaps billions, of dollars. Imagine in this climate of preservation and restoration, roads and bridges — even airfields — that hold up for several decades with little damage.

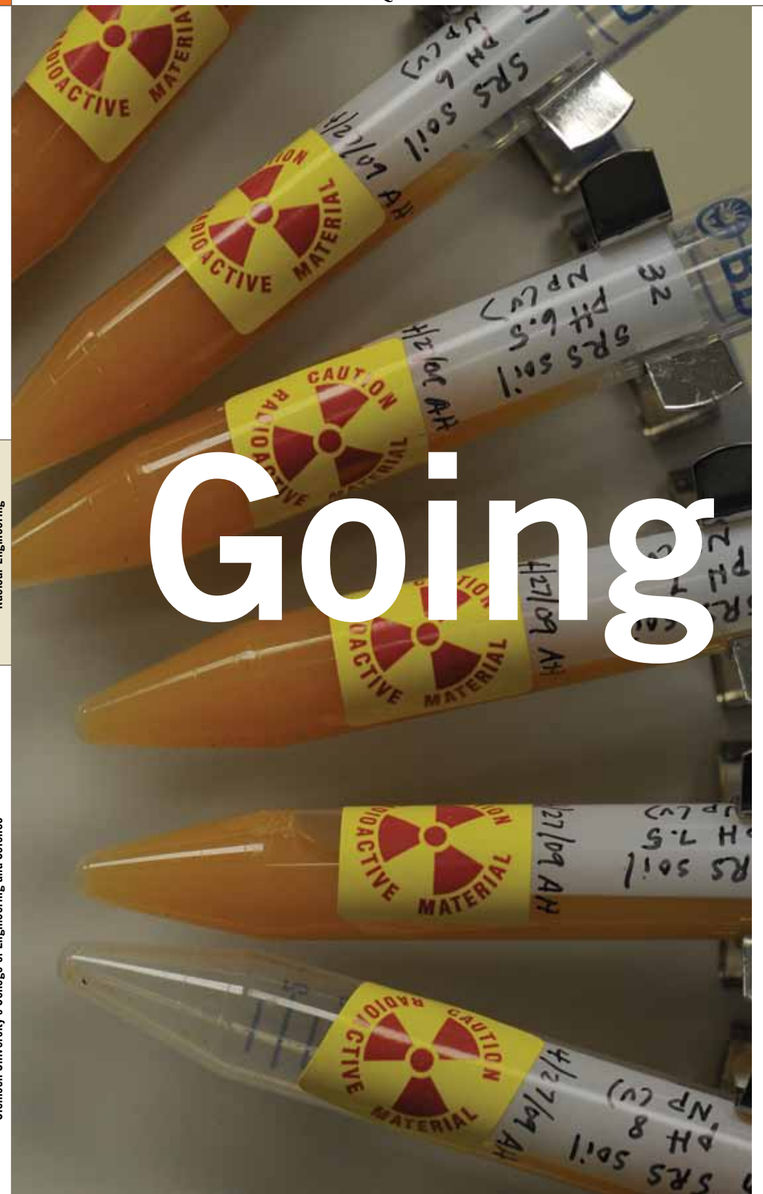
In a related story, our Asphalt Rubber Technology Service is finding ways to promote, design and test the use of recycled scrap tires in rubberized asphalt and other civil infrastructure applications. Rubberized asphalt that uses scrap tires is cost effective and has a long-term life cycle. But perhaps best of all, it's environmentally friendly.

Academic "infrastructure" is about more than bricks and mortar. To be successful, you have to have quality people with creative ideas and the excitement and drive to turn knowledge to products. In this issue of *IDEaS*, we premier a new feature that will run periodically on "Clemson Couples," highlighting College of Engineering and Science professors who successfully share dual academic careers. As these young professors develop their careers, we look forward to seeing how their work impacts the University, state, region and world.

Sincerely,



Esin Gulari, Dean
College of Engineering and Science
Clemson University




# Going Nuclear

*By Ron Grant*

He graduated from high school three years after Three Mile Island and entered graduate school in nuclear engineering one year after Chernobyl. With what, in hindsight, appeared to be ominous road signs against pursuing such a career path, Timothy DeVol, a professor in Clemson's Department of Environmental Engineering and Earth Sciences (EEES), decided that those momentous events signaled a need for good people in the industry, so he persevered. As a researcher in Clemson's nuclear environmental engineering and science (NEES) graduate program, DeVol is preparing others to enter the nuclear field.

Traditional nuclear engineering programs exist in stand-alone departments or under the auspices of a mechanical engineering department, but at Clemson, this work is being carried out in an unusual and highly effective way.

"What makes our program unique is that we're a nuclear program imbedded in an environmental department, and we think that's a great place to be," observes DeVol. "A lot of the issues facing the industry today have to do with radioactive contaminants in the environment, and what better place to explore those phenomena and their impacts than where researchers understand the environment and the movement of contaminants therein?"

## How it all began

This exceptional program came about because of South Carolina's unique position as a home to a variety of nuclear-based industries. In the 1950s, the federal government established the Savannah River Site (SRS), a defense facility that initially housed five operating reactors and highly advanced separation facilities. By the early 1970s, South Carolina-based utilities turned to nuclear power generation.

Currently, there are seven licensed commercial reactors in the state generating 65 percent of the electrical power. Westinghouse established a nuclear fuel assembly plant in Columbia and has plans for an advanced fuel fabrication operation in the Upstate. Barnwell County is home to a commercial low-level nuclear waste storage facility — one of only three in the country.

"Clearly South Carolina established what could be called a nurturing environment for nuclear-based industry, and Clemson saw that there would be a need for research support for these entities," says Robert Fjeld, the Dempsey Chair of Environmental Engineering at Clemson. Fjeld was recruited from Texas A&M to begin Clemson's NEES graduate program.

"Traditional academic nuclear engineering programs dealt with the physics of what transpires inside reactors," says Fjeld. "Our focus is providing students with the skills they would need to address the environmental issues associated with power production."

Although the early emphasis of Clemson's academic program was established to support the power industry, there are research needs waiting in the wings in other areas.

## Thinking outside the nucleus

In the late 1980s, concern about indoor radon arose, and the Environmental Protection Agency (EPA) had funds for universities to study indoor radon problems. Thus, Clemson expanded its nuclear environmental engineering and science faculty and their research capabilities.

Early in the life of Clemson's nuclear environmental engineering and science program, an internship program had been established with SRS. As the Department of Energy's (DOE) mission at SRS moved from production to environmental remediation, Clemson was in a position to strengthen its relationship with the site.

"Basically, the DOE had this huge, complex site that required remediation, and they realized a need for instrumentation for measuring radioactivity in environmental settings," says Fjeld. "So we wrote a proposal that was funded by the DOE's Office of Technology and Development. What came out of that was a really neat system for measuring multiple radionuclides that undergo different types of decay of a single analysis of an environmental sample. That five-year project was another big boost because it was major funding — it covered a lot of students as well as some postdocs."

Another innovation that came out of Clemson's growing relationship with the DOE and SRS had nothing to do with hardware or instrumentation. It was the establishment of the South Carolina Universities Research and Education Foundation (SCUREF).

"Our focus is providing students with the skills they would need to address the environmental issues associated with power production," says Fjeld.

## Nuclear In-depth

Clemson's NEES program encompasses the environmental aspects of nuclear technologies. NEES students have two focus areas in which to work – environmental health physics and environmental radiochemistry.

The environmental health physics program (ABET/ASAC accredited) emphasizes radiation protection, radiation detection and measurements, risk assessment and radioactive waste management.

The environmental radiochemistry program emphasizes actinide chemistry, radionuclide geochemical behavior chemical separation in the nuclear fuel cycle and analytical radiochemistry.

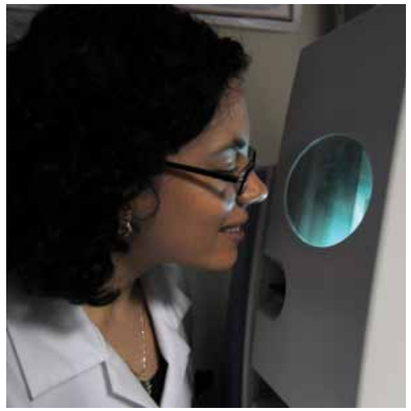
The NEES focus area is fully integrated within the environmental engineering and earth sciences department. This arrangement provides course work and expertise in important complementary areas such as contaminant transport in the environment, environmental chemistry, process engineering, hydrogeology and geochemistry.

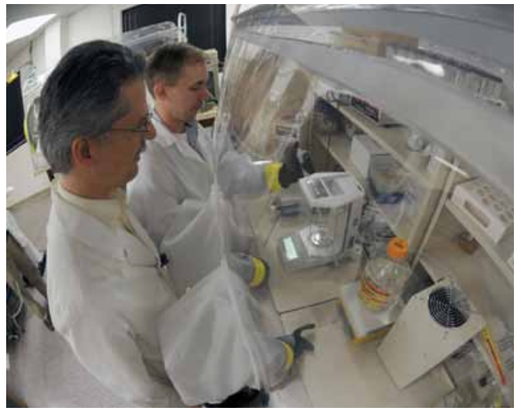
Alumni of this program are employed by environmental consulting firms, the DOE and its contractors, the NRC, nuclear utilities and regulatory agencies.

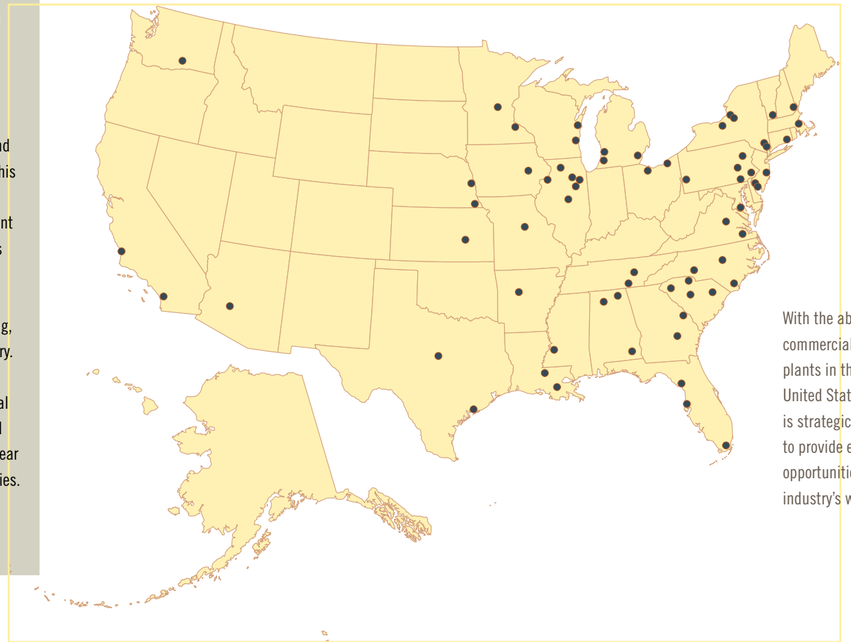
"SCUREF was established to provide a single entity through which the site could work with universities in the state," says Fjeld. "It made the transfer of research funds much, much easier, and helped us strengthen our relationship with the site."

Initially, Clemson's NEES program focused on health physics, radiation detection and measurements, risk assessment and radioactive waste management. Clemson expanded the program to include a radiochemistry emphasis in 2000, in reaction to a 30-year decline in the number of trained nuclear scientists and radiochemists able to support the nation's current needs in the discipline.

One of the first recruits to the expanded program was Brian Powell. Three years after completing his Ph.D., Powell returned to Clemson to head the environmental radiochemistry emphasis area.







With the abundance of commercial nuclear power plants in the eastern United States, Clemson is strategically located to provide educational opportunities for the industry's work force.

"I had actually intended to work at one of the national laboratories for most of my career," offers Powell. "However, I found that I missed interacting with students. The program provides a unique environmental focus that more traditional programs do not — a focus that's meeting critical manpower needs. The nation is facing serious staffing shortages in environmental radiochemistry, advanced nuclear fuel cycles, nuclear medicine, isotope production, waste treatment, health physics and homeland security applications."

### What's next?

Today, South Carolina finds itself again in the midst of a burgeoning nuclear industry. The DOE is building a $4 billion mixed-oxide fuel facility at SRS. This facility will be a major component in the U.S. program to dispose of surplus weapons-grade plutonium, by converting it into fuel for reactors. On the commercial side, many reactors that began operation in the late 1960s and 1970s are applying for 20-year license extensions. When combined with a current work force nearing retirement, these extensions make job prospects for NEES graduates excellent.

The Oak Ridge Institute for Science and Education indicates that the yearly number of graduates in health physics averages about 200 people per year. The Nuclear Regulatory Commission (NRC) has stated that it requires about 300 health physicists a year over the next several years — and that doesn't include workers required by the nuclear power industry.

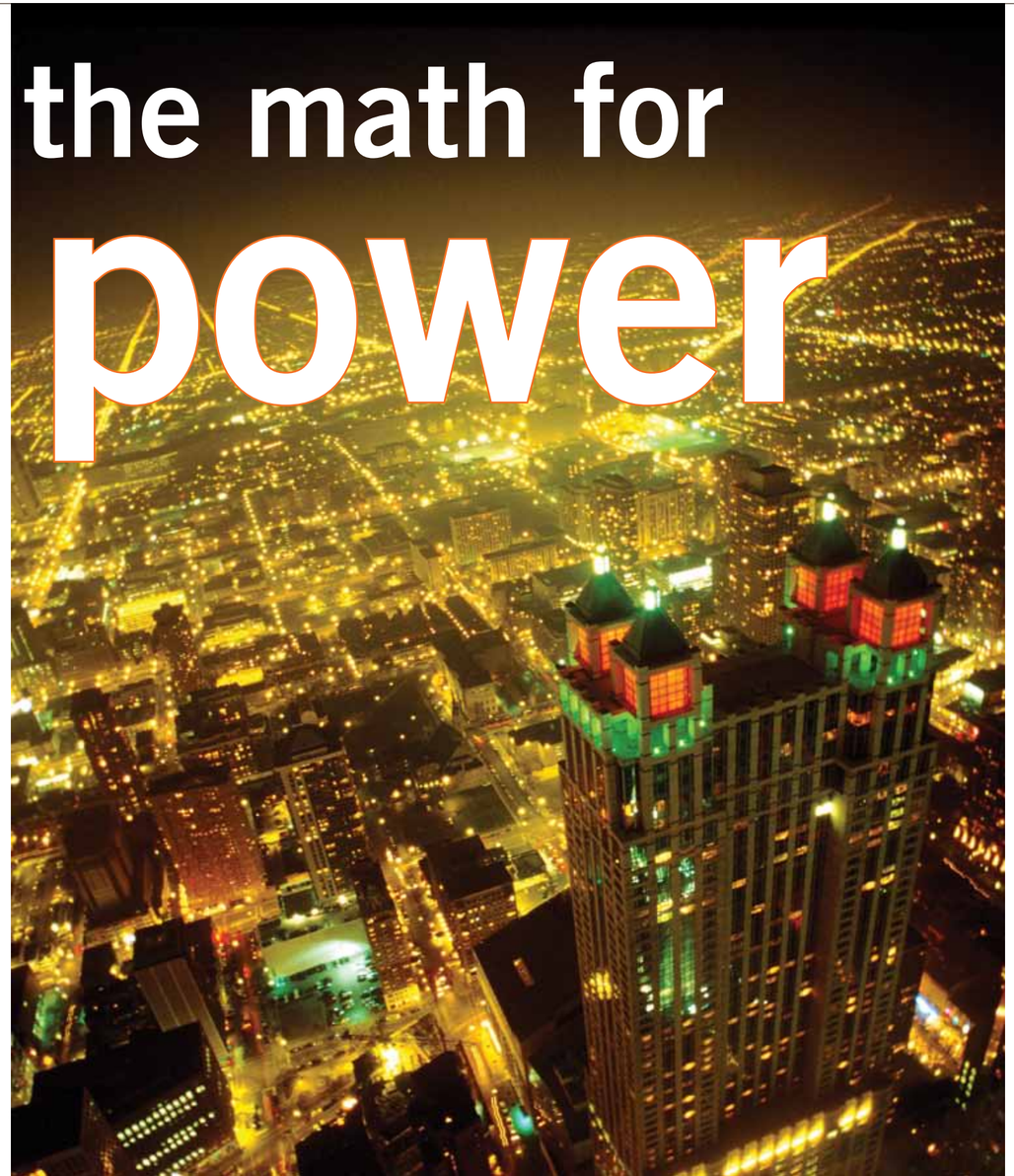
Both the NRC and the DOE have recognized the critical need for workers and have established funding programs to support academic programs like Clemson's. Over the past three years Clemson has received funding from the NRC and the DOE Office of Nuclear Energy to broaden the pool of candidates needed in the nuclear industry.

"These funds will provide for graduate students who'll become the next-generation nuclear work force, specifically in radioactive waste disposal, radiochemistry and the environmental aspects of nuclear power generation," says DeVol. "Expertise in these areas is a critical issue because of attrition as well as possible expansion of the nuclear power industry." *

Left to right: Ph.D. student Amy Hixon observes plasma during analysis of a sample by inductively coupled plasma-mass spectrometry. Graduate student Todd Miller and Professor Brian Powell discuss experiment results that examine radionuclide sorption to sediments from the Savannah River National Laboratory. Professor Robert Fjeld studies radionuclide uptake and translocation in vegetation. Ph.D. student Kelly Grogan and Professor Timothy DeVol prepares extractive scintillating resins for online detection of radionuclides.

# Doing the math for smart power

*by Liz Newall*



There should be a way to reduce power usage (and power bills!), help the environment and become more energy independent — without giving up comfort and convenience.

Clemson researchers believe there is.

Mathematical sciences professors Taufiquar Khan and Irina Viktorova have gathered a team of Clemson students for a project to make smarter electric power networks for the nation's need to boost the economy and ecology.

They're working with the support of industry partner Itron Inc., a leading technology provider and critical source of knowledge to the global energy and water industries. Itron's OpenWay platform combines the best available solutions from the smart metering and advanced metering infrastructure technologies.

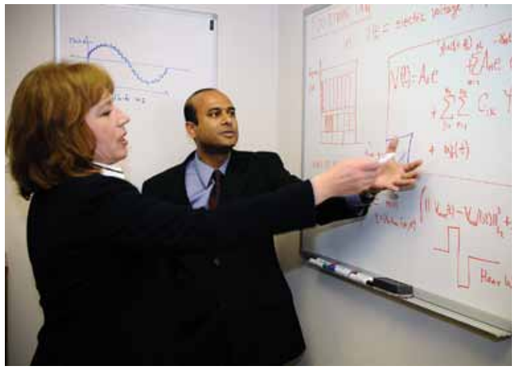
"With the ability to monitor the entire power grid in real time," says Viktorova, "the utility can ensure uninterrupted service, improve distribution efficiency, save energy and reduce operating costs."

The method of operation? Fundamental math — through mathematical models.

## Natural Oscillations

Millions of light bulbs, computers, televisions, appliances, heaters and electrical motors are constantly going on and off. They contribute to the disorderly pattern of variations of voltage, current and impedance of the alternating current network.

The expected outcome of the research is smart meters that can efficiently record usage over 15-minute intervals resulting in consumer savings on electricity bills.



By creating mathematical models of complex power-distribution networks, the Clemson team is searching for new information that may help to improve the electrical distribution system.

### Solving problems — a team effort

The team includes graduate students and postdoctoral researchers, as well as faculty. In addition, it involves a Creative Inquiry team of undergraduates.

Itron is providing $285,000 of financial backing, advanced measurement tools, access to cutting-edge technology and general technical support.

Mathematical sciences graduate student Jack Cooper is performing sparse signal representation in electrical power system signals. His mission is twofold: to use the latest mathematical techniques to model the power system waveforms, and to do so with the smallest amount of stored information.

Statistics graduate student Chendi Jiang is performing noise modeling in electric power system signals. Physics graduate student Jason Puls is working with fast real-time measurements of electric voltage and current.

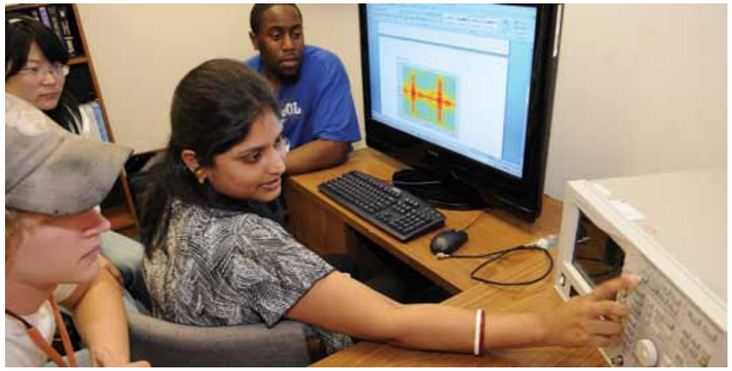
Electrical and computer engineering graduate student Zhenhua Wang is building a physical model of the power systems waveforms. Xiaoxiao Huang, another electrical and computer engineering graduate student, provides engineering feedback on vector signal analyzer measurements.

Computer science graduate student Dhruba Kulkarni is working with large data sets that need to be analyzed and classified. He also provides IT help to other team members.

Undergraduate student Josh McGinnis is the Creative Inquiry project leader. The Creative Inquiry work has three teams of undergraduate students in a variety of majors. One team measures data from the vector signal analyzer. Another team analyzes the data. A third team provides in-depth information to solve the formulated problem (provided by professors Khan and Viktorova).

### Greater $avings — fewer blackouts

"Our overall research goal is to model the smart electric power grid network on a micro scale, starting with a single node, to the macro scale of the entire grid," says Khan.



Far left: Professors Taufiquar Khan and Irina Viktorova.

Right: Mechanical engineering undergraduate student Austin Bray (left) meets with research assistants on the Creative Inquiry project "Evolution of Integral Transforms and Their Applications." Research assistants on the CU-Itron project include (from left to right): mathematical sciences graduate student Chendi Chen, electrical engineering undergraduate student Antonio Baylock and electrical engineering graduate student Vinati Kodukula.

### Best job in America today — mathematician!

In the recent "The 10 Best Jobs in America Today," JobsRated.com picks mathematician as No. 1. In fact, five of the top 10 are mathematically related. (See *www.careercast.com/jobs/content/JobsRated_10BestJobs.*)

### Doing the math at Clemson

Clemson's mathematical sciences department is doing its part to prepare students for these top jobs. In the process, it provides major contributions to the overall instructional and research mission of the University.

Enrollments average 5,000 to 6,000 students per semester in more than 300 sections of math sciences courses, ranging from beginning freshman courses to cutting-edge advanced courses at the graduate level.

Prominent research activities include more than 100 publications a year, national and international professional involvement, and funded research of more than $1 million.

Clemson has 250 smart classrooms interspersed around campus that enable the sharing of work to solve problems and foster collaboration. They also facilitate online quizzes — either in or out of class — and accommodate mathematical simulation environments.

Degree programs are organized by discipline into five areas in the mathematical sciences: algebra and discrete mathematics, applied analysis, computational mathematics, operations research, and probability and statistics.

The modeling will help optimize the efficiency of the power grid as well as prevent system failure such as blackouts.

The short-term research is one year. The expected outcome is smart meters that can efficiently record usage over 15-minute intervals resulting in consumer savings on electricity bills.

The long-term research of modeling the entire power grid and developing information theory for the complete network will require a number of years. The possible outcome is a computationally efficient mathematical model of a smart electrical distribution network that can lead to new sensing and control technologies for the smart grid.

"Mathematical modeling has proven its feasibility as an efficient tool of optimization," says Vladimir Borisov, Clemson's technical liaison and senior principal engineer with Itron. "The Clemson project promises to be instrumental to our continual effort to improve performance and reliability of Itron's products." *

# Save the Concrete

*By Susan Polowczuk*

A savings of millions, even billions of dollars, that's what Clemson University research on the durability of concrete infrastructure could potentially do. Imagine in this climate of preservation and restoration, roads and bridges, even airfields that hold up for several decades with little damage.

Associate professor of civil engineering Prasad Rangaraju, in collaboration with Purdue University and Professional Service Industries Inc., has received a four-year, $1.1 million grant from the Federal Highway Administration to better understand the durability challenges facing concrete infrastructure and to develop new test methods to address them.

"At Clemson, we will be studying alkali-silica reaction (ASR) in concrete," says Rangaraju. "This is a durability problem that arises due to incompatibility between ingredients that make up concrete. How the ingredients in concrete interact with each other — as well as with the environment in which they serve — determines a lot about how long materials will last in the elements."

Rangaraju says improper selection of raw materials used in concrete can result in ASR distress. For instance, when concrete mixtures with incompatible materials are prepared, the alkali-silica reaction in concrete can result in excessive expansion and/or extensive cracking in the structure. He adds that once ASR affects a concrete structure, it is difficult to repair.

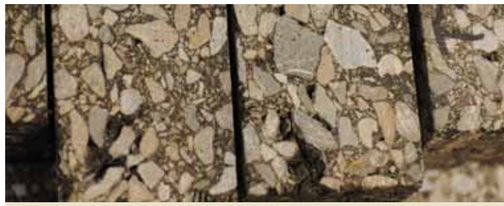
"So you're left with options of either replacing the structure or conducting expensive repair and rehabilitation operations," says Rangaraju.

Rangaraju and Clemson University have a long history of studying concrete deterioration. In previous studies, he and his group concluded that the deterioration of concrete pavements in airfields in the form of cracks, expansion and popouts can be accelerated when acetate and formate salts of potassium and sodium are used in deicing and anti-icing operations. It is the combination of these chemicals interacting with the ingredients of the concrete that can cause deterioration.

Based on technology invented by Rangaraju, South Dakota Transportation research scientist Daniel Johnston and a team of FMC Lithium researchers, FMC Lithium recently developed a lithium-modified potassium acetate deicer called LithMelt™. The Clemson University Research Foundation licensed the technology to the FMC Corp., Lithium Division. Laboratory studies and field trials have shown that LithMelt™ deicer is as effective as other deicers, without any damaging impact on concrete pavements and the environment.

"We've looked at problems of crumbling airfield pavements for years now, and the FAA is determined to slow or halt the deterioration — which can cost millions," said Rangaraju. "In addition, accidents due to icing on roads, bridges, airport runways and other surfaces cause serious injury and fatalities. We believe this technology will go a long way toward alleviating needless suffering. There are also savings associated with reduced maintenance costs and the increased service life of the infrastructure. Ultimately, the impact of this deicer in improving the safety of operations on airfield pavements is most exciting to our team." *

When concrete mixtures with incompatible materials are prepared, the alkali-silica reaction in concrete can result in excessive expansion and/or extensive cracking in the structure.



## ARTS

The Asphalt Rubber Technology Service (ARTS) at Clemson University was created to promote, design and test the use of recycled scrap tires in rubberized asphalt and other civil infrastructure applications. Such applications can include use in playground and roadway surfaces among other things.

Recycling tires is important because approximately 300 million scrap tires are produced annually in the United States. When buried in landfills, they tend to work or "float" their way up to the top of the landfill and become exposed again. Exposed tires are breeding grounds for mosquitoes, and they are fire hazards. A typical passenger tire weighs 20 pounds, and with 230 million scrap passenger tires generated per year, 2.2 million tons of waste are produced.

ARTS is a partnership between South Carolina's Department of Health and Environmental Control and Clemson University. It provides funding to South Carolina cities and counties for several test projects, performs research to discover new uses and improve upon existing uses of scrap tires, conducts training classes and seminars, and promotes technology transfer.

ARTS Director Serji Amirkhanian promotes the use of old tires in polymerized or rubberized asphalt, which is mechanically or chemically enhanced for better performance.

"It has a longer life cycle," says Amirkhanian. "It's costly at first but is a better product that can withstand heat and cold and doesn't crack or flex as much. Best of all, it's environmentally friendly."

Amirkhanian lectures in places such as China, Europe, Honduras and Canada, promoting polymerized asphalt and research opportunities at ARTS. He says in the United States, Florida, Arizona, California, Texas and now New Jersey are all on board with the product, and South Carolina's Department of Transportation has the specification for the material.

BRIAN AND DELPHINE DEAN SHARE MORE THAN A LAST NAME. THEY'RE TWO OF CoES'S MOST DISTINGUISHED ASSISTANT PROFESSORS WITH A STRONG PASSION FOR RESEARCH.

# Following the Deans

*By Stephanie Williams*

**Brian and Delphine Dean** have more in common than just a last name. They are two of the College of Engineering and Science's (CoES) most distinguished assistant professors who also happen to share a dual academic career, an extensive list of awards and accolades, and a passion for research.

It is usually difficult for assistant professors who are married to one another to find positions at the same academic campus. Not only is it rare, but also extremely tough for the professors to find positions within the same college or school. Luckily for the Deans, they were both able to find homes at Clemson University within CoES.

The couple met more than 10 years ago during their undergraduate studies at the Massachusetts Institute of Technology (MIT) through mutual friends while residing in the same dorm. The couple married in 2000 and continued to pursue their careers in academia. They both applaud Clemson's support for couples.

"Clemson University is one of the most accommodating institutions for dual academic careers," says Brian. "Many of our friends who were searching for dual appointments weren't as lucky as we were, and they're currently located hundreds of miles (if not thousands) away from their spouses."

Brian and Delphine received their master's and doctoral degrees at MIT in electrical engineering and computer science (EECS), both winning prestigious awards during their course work. While they started their research careers at the same place, they eventually found their own niches to explore. Brian focuses primarily on the development of approximation algorithms for a variety of hard computational problems, while Delphine focuses on measuring and modeling nano- to micro-scale biological mechanical phenomena. For example, she has done work characterizing the molecular interactions responsible for mechanical properties of cartilage tissue.

> The couple believes there are many benefits to having dual academic careers at the same university. The Deans are currently collaborating on a project using machine vision technology to analyze the cytoskeletal structure of cells and using that to build computational models of cell mechanics.

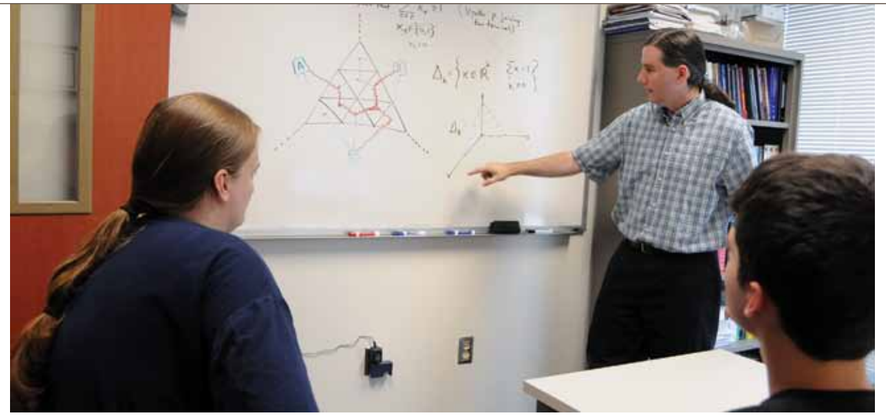
Brian received his Ph.D. in computer science in 2005 and began a postdoctoral associate position at MIT. After receiving her Ph.D. in electrical engineering and computer science, Delphine began working at MIT as a postdoctoral associate in bioengineering.

"Once I received my Ph.D., I began looking for assistant professor positions that were available all over the country," says Brian. "Clemson seemed like the best fit due to the amount of collaboration taking place between departments within CoES. It's a very supportive academic and social community."

Brian currently serves as an assistant professor of computer science, which is housed in the School of Computing. His research interests are quite broad, covering both theoretical and applied aspects of algorithmic computer science and combinational optimization. In addition, he is interested in developing enhanced multimedia content for computer science education and advancing computer science education at the high school level.

Delphine accompanied Brian to Clemson where she began a postdoctoral fellowship in the bioengineering department. She soon won the Biomedical Engineering Society Poster Award and became an assistant professor within the department. Her main research interests include biological

Delphine Dean, with students Matt Cupelli and Laura Wiles, makes measurements on the thermal conductivity of teeth for a project to model heat conduction in teeth during drilling.



Brian Dean works with Ph.D. student Adam Whitley and undergraduate Ben Cousins on simplex embeddings for multiway cut problems.

"Clemson University is one of the most accommodating institutions for dual academic careers," says Brian Dean.

nanomechanics, cell-cell and cell-matrix interactions, computational modeling and bioinformatics. Delphine was named the Bioengineering Class of 2009 Favorite Clemson University Undergraduate Research Advisor.

The couple believes there are many benefits to having dual academic careers at the same university. The Deans are currently collaborating on a project using machine vision technology to analyze the cytoskeletal structure of cells and using that to build computational models of cell mechanics.

"Being in separate departments allows us to collaborate, but not step on each other's toes," says Delphine. "We are able to read over grant proposals, provide honest feedback, and most importantly, we both understand the workload and demand that academia requires."

Both of the Deans have received many awards and accolades during their academic careers. Recently, Brian received an NSF CAREER award, which is one of the most prestigious awards given by the NSF to young faculty members. This five-year award will help support Brian's algorithmic research as well as launch a new initiative to promote computing education at the early high school level. He was also recently honored with the College's Award of Excellence for Teaching in the Sciences, which recognizes excellence in teaching at the undergraduate and/or graduate level with emphasis on the most recent three years. Delphine is the recipient of an NIH K25 grant. Her main research goal involves studying cardiac cell mechanics.

When the Deans aren't in the lab, advising undergraduates or teaching courses, they enjoy a variety of other activities. Brian is a pianist who tries to find time to perfect his skills, and Delphine takes figure skating lessons twice a week. Together, they enjoy hiking, attending local festivals and cooking — they're self-proclaimed "foodies." The couple also has two tabby cats, Nano and Newton, whose names should come as no surprise.

"We try to find time to do some of the things we love outside of academia," says Delphine. "Clemson's geographic location allows us to do a lot of things we enjoy such as hiking and many other activities the area has to offer."

The couple is looking forward to continuing on their tenure tracks at Clemson as well as the new research opportunities they will encounter.

"Our disciplines are always evolving, and there is new research that comes as a result," says Delphine. "We're looking forward to what the future holds for us and finding new ways to combine our separate interests to collaborate on more projects." *



# News and notes

## CoES researchers receive NSF CAREER awards

The Faculty Early Career Development (CAREER) Program offers the National Science Foundation's (NSF) most prestigious awards in support of the early career-development activities of teacher-scholars. Four College of Engineering and Science (CoES) faculty were honored with CAREER awards this spring.

**Brian Dean**, a professor in the School of Computing, received his NSF CAREER grant to research and develop more efficient algorithms for a wide range of computational problems. His research will focus on a class of computational challenges known as matching problems, such as assigning students to classes, directing traffic to Web servers or matching donor kidneys between families participating in an organ-exchange network. His goal is to develop simpler and more efficient algorithms to solve these problems in which most of the participants are assigned to one of their highest-preferred alternatives.

**Shelie Miller**, an assistant professor in the Department of Environmental Engineering and Earth Sciences, received her NSF CAREER award to further her research in life-cycle assessments. In her work, she identifies an item's life-cycle steps, ranging from raw materials through disposing or recycling. She then evaluates a product's cumulative impact on the environment. Life-cycle assessments provide industry and public leaders with "cradle to grave" analyses of how products and processes affect the environment. Miller is currently analyzing switchgrass, a hardy perennial grass that shows a lot of promise as a biofuel. To be a viable option to fossil fuel, a biofuel needs to be economically competitive and producible in large quantities without reducing food supply.

Assistant professor of mechanical engineering **Lin Ma** has been awarded an NSF CAREER award to study turbulent combustion, the mode of combustion in many practical energy-generating devices. The project aims to understand its complicated physics, which will contribute to the solution of pressing global issues of energy security and environmental sustainability. The complexity of chemical reactions in turbulent flows is found in an incredibly wide spectrum of real-world devices — from the simple (such as barbecue grills), to the complicated (such as industry boilers power plants and aircraft engines).

Assistant professor of chemistry **Rhett Smith** received his NSF CAREER award to advance the construction of plastic electronics. His focus is a new class of materials that have well-defined and tunable molecular-level organization of organic and hybrid organic/organometallic materials. Such compounds are used to create photovoltaics, light-emitting devices and lightweight solar cells. This project will also increase awareness in physical science through the development of two polymer science courses and an outreach program for Clemson undergraduates and underrepresented high school students in South Carolina.

## DOE funds Clemson, Savannah River National Laboratory hydrogen research

The U.S. Department of Energy (DOE) has awarded Clemson University researchers — in collaboration with DOE's Savannah River National Laboratory — funding to develop a new polymer membrane that may enable the production of hydrogen using high-temperature heat, such as that from a nuclear reactor.

Clemson chemist **Dennis Smith** will lead the program to develop a new fluoropolymer material that can withstand the harsh conditions in the electrolyzer, which is used to react sulfur dioxide and water to produce hydrogen and sulfuric acid. Membranes will be supplied to Savannah River National Laboratory scientist David Hobbs and his group for evaluation.

"Hydrogen could be a major source of energy in the future, and the DOE is exploring infrastructure now for that possibility," says Smith. "Advanced materials like polymers will help enable this and other membrane technology in fuel cells, water purification and simple batteries."

## Geoscientists Without Borders tackle water project in India

India and Thailand are sites for the first two projects sponsored by the Geoscientists Without Borders program, and Clemson University researchers will lead the way in India, addressing a severe water crisis in rural areas.

"The lack of fresh water is a chronic problem in central India that has impacted the health, productivity and quality of life for millions of people living there," says **Stephen Moysey**, from the Department of Environmental Engineering and Earth Sciences.

Moysey expects to go to the area in the spring with Dan Matz, an environmental engineering and science graduate student. The pair will spend six months working with villagers and Foundation for Ecological Security staff in the watershed.

The program sponsors efforts to apply geophysical technology to address the needs of people in developing countries around the globe, specifically targeting projects that have a humanitarian impact on communities.

## Physicist named Fellow of the American Physical Society

Professor of physics and astronomy **Apparao Rao** has been named a Fellow of the American Physical Society. Fellows are elected by their peers for outstanding contributions to physics. Fellowship is limited to no more than one-half of 1 percent of the membership.

Rao was recognized for developing methods of synthesizing carbon nanotubes and for elucidating the properties of carbon nanotubes through Raman spectroscopy, a technique used in condensed-matter physics and chemistry to study vibrational, rotational and other low-frequency modes in a system.

Rao and his team have gained international recognition for advancing nano-scale electromechanical sensors that have the potential to read and issue alerts about levels of different toxic chemicals or gases in the air.

## BMW Endowed Chair named AAAS Fellow

**Thomas R. Kurfess**, the BMW Endowed Chair in Manufacturing, has been named a Fellow of the American Association for Advancement of Science (AAAS). Election as a Fellow is an honor bestowed upon AAAS members by their peers.

In the area of engineering, Kurfess was elected for distinguished contributions to the field of manufacturing systems and precision engineering, particularly advanced process development and quality control for global production systems.

Kurfess' research at the Clemson University International Center for Automotive Research focuses on advanced production systems, process control and process diagnostics, and prognostics to ensure vehicle performance. His work also extends to advanced vehicle stability and control.

## Industrial engineering introduces first-of-its-kind online graduate program

Tough economic times are not keeping an unusual group of Clemson graduate students out of the classroom. In fact, they are benefiting from the convenience and camaraderie of a global classroom experience.

The master of engineering with a concentration in capital projects supply chain and logistics offered in the industrial engineering department is a first-of-its-kind online graduate program that allows working professionals from around the world and across the spectrum of disciplines to sit in a virtual classroom any time of the day or night that best fits their schedule.

"The degree is unique in that it focuses on the logistics of capital projects engineering and construction, combining theory with practice to broaden student understanding of the entire project supply chain and life cycle," says Bill Ferrell, professor of industrial engineering and associate dean of the graduate school.

Capital projects are generally defined as new construction, expansion, renovation or replacement of an existing facility or facilities and infrastructure. Land, engineering, architectural planning and services needed to complete the project all are part of the cycle. The program represents and explores the various roles and interests in the execution of capital projects, including owners, contractors, suppliers and subcontractors.

The program was developed in collaboration with the civil engineering and management departments at Clemson, as well as with owners, contractors and suppliers such as Fluor Corp., Chevron and Mobil.

## Chemists present revolutionary teaching concepts

Clemson University researchers want to strengthen chemistry skills starting at the molecular level and are introducing revolutionary ways for educators to do that for students at the high school and college levels.

Clemson chemistry professors **Melanie Cooper** and **Gautam Bhattacharyya**, along with Michael W. Klymkowsky, a professor in the Department of Molecular, Cellular and Developmental Biology at the University of Colorado-Boulder, introduced their research at the American Association for the Advancement of Science annual meeting in Chicago.

Cooper and Klymkowsky were awarded an NSF grant for a three-year project to develop Chemistry, Life, the Universe and Everything (CLUE), a new general chemistry curriculum that will use the emergence and evolution of life as the scaffold and context for introduction of chemistry concepts.

## Associate dean joins ORAU Board of Directors

**R. Larry Dooley**, associate dean for research and graduate studies in CoES, has been elected to the Oak Ridge Associated Universities (ORAU) Board of Directors. In joining the board, Dooley brings 35 years of academic and industrial expertise.

ORAU is a university consortium of 100 major research institutions that works with national laboratories, government agencies and private industry to leverage strength to advance science and education. ORAU manages the Oak Ridge Institute for Science and Education for the U.S. Department of Energy.

"I am extremely pleased to serve ORAU and Clemson University in this leadership position," says Dooley. "ORAU is a model for university-national lab collaborative partnerships which, at this critical time, are vitally important for strengthening science and education programs in the United States. I welcome the opportunity to work with my colleagues on the board."

Dooley joined Clemson in 1985 as professor of bioengineering and as the research director for the Bioengineering Alliance of South Carolina. He has organized a pre-award processing division that supports 250 researchers in engineering and science. Editorial support and grant planning to provide an integrated approach to proposal development and increased funding are also part of his mission.

## Engineering and science students named Goldwater Scholars

Three Clemson University students have earned the prestigious 2009 Barry M. Goldwater Scholarship for Excellence in Science, Mathematics and Engineering. Only 278 students were selected for the scholarships from a nationwide pool of more than 1,000.

The scholarship program honoring Sen. Barry M. Goldwater was designed to foster and encourage outstanding students to pursue careers in the fields of mathematics, engineering and the natural sciences.

The Clemson awardees are James Hodges, a junior from Sumter, working on a double degree in chemistry and polymer and fiber chemistry; Michael Juang, a junior from Clemson, studying electrical engineering; and Jennifer Moffitt, a sophomore from Spartanburg, studying chemical and biomolecular engineering.

Approximately one-third of the Goldwater Scholarships are awarded to sophomores with the remaining two-thirds going to juniors.

INQUIRY, DISCOVERY IN ENGINEERING AND SCIENCE

IDEaS

FALL 2009

IDEaS is produced biannually for the College of Engineering and Science at Clemson University by the Office of Creative Services.

On the cover: Graduate student Shannon Thompson examines corn roots from a study of plutonium uptake and translocation in vegetation.

Right: Prasad Rangaraju places a concrete sample into an electron microscope. More on page 10.

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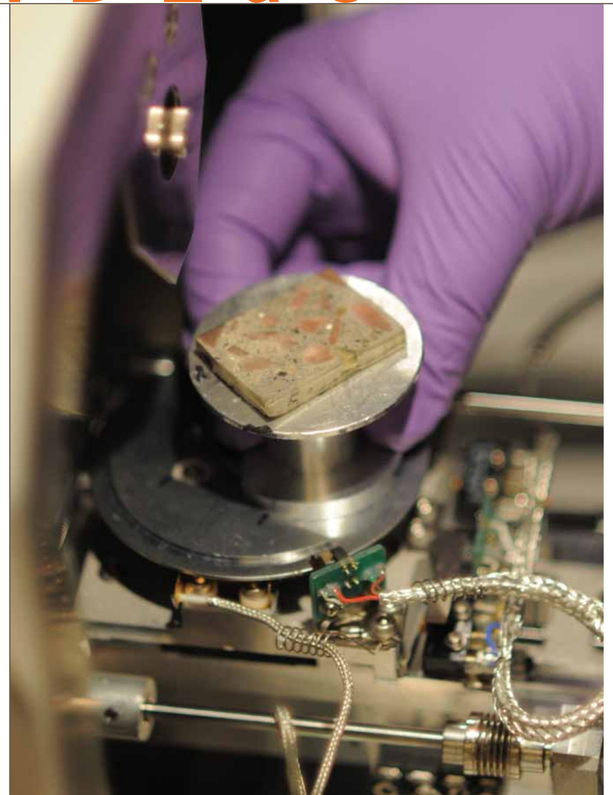
College of ENGINEERING AND SCIENCE



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Left to right: Dr. R. Larry Dooley, Dr. Esin Gulari, Dr. E.R. (Randy) Collins

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# IDEaS

INQUIRY, DISCOVERY IN ENGINEERING AND SCIENCE

COLLEGE OF ENGINEERING AND SCIENCE FALL 2009

## Highlights from our departments

# College Structure Is Key to Collaboration

The College of Engineering and Science is made up of 14 separate schools and departments, but the unique structure of combining engineering and science programs within one college has led to an uncommon ability to provide a team-based, integrated approach to teaching and research. Scientists and engineers working together to find more efficient solutions is the structure of Clemson University's College of Engineering and Science.

# Bioengineering

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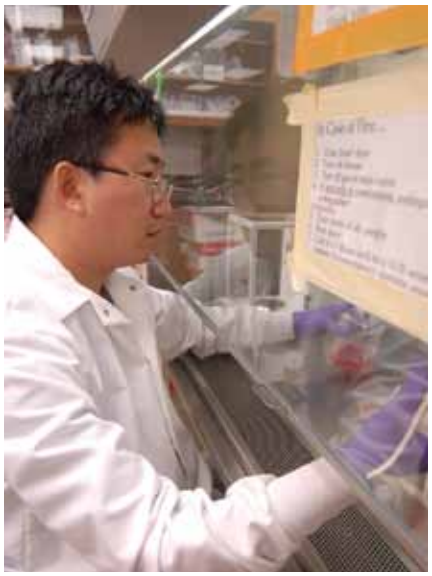
## Fast Facts

**Tenured/tenure-track faculty:** 22

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 131 |
| | Master's | 16 |
| | Doctoral | 73 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 24 |
| | Master's | 10 |
| | Doctoral | 12 |

**Research expenditures:** $4,924,428
**Research thrusts:** biomaterials, tissue regeneration, emerging technologies for health care, bioimaging



Professor **Xuejun Wen** is a recipient of an NSF CAREER award for his research in stem cell viability.

## Department Overview

Clemson's Department of Bioengineering has a rich tradition of globalization and international outreach. In 1969, Clemson hosted the first in a series of annual symposia (later known as the annual International Biomaterials Symposium) that led to the founding of the Society For Biomaterials (SFB) in 1974. Now the world's premier professional society in promotion of advances in all phases of materials research and development, the SFB encourages cooperative educational programs, clinical applications and professional standards in the biomaterials field.

Our academic mission is to provide high-quality undergraduate and graduate bioengineering education programs that prepare students to 1) apply science and engineering principles to solve problems in biology and medicine, 2) generate and disseminate knowledge to benefit humankind and 3) apply that knowledge toward improving health care and scientific and technological development.

## Faculty Highlights

The NSF named professor **Xuejun Wen** a recipient of its CAREER award for his research in stem cell viability. His novel strategy is based on the idea of manipulation of the brain's microenvironment before stem cell transplantation and again afterward to create a niche suitable for the long-term survival and function of the transplanted cells. Wen works at the Charleston branch of Clemson's Department of Bioengineering in conjunction with the Clemson University-Medical University of South Carolina (CU-MUSC) bioengineering program. His previous research led to international recognition and funding from a number of organizations, including the Michael J. Fox Foundation.

**Martine LaBerge**, professor and chair of bioengineering, has been named the recipient of the 2009 South Carolina Governor's Award for Scientific Awareness. The award was established in 1985 by the Drug Science Foundation to honor individuals or teams in South Carolina whose achievements and contributions to science merit special recognition and promote wider awareness of the quality and extent of scientific activity around the state. LaBerge has initiated many S.C. programs that have served as platforms to increase awareness among the scientific community as well as the public.

## Student Achievement

**Laura Datko** (inaugural bioengineering bachelor's class) was awarded an NSF Graduate Research Fellowship to conduct doctoral studies in bioengineering under the supervision of Delphine Dean. Datko's graduate work will focus on biomaterials and biomechanics for dental applications.

**Michael Lemus** (inaugural bioengineering bachelor's class) was selected for a Howard Hughes Medical Institute Exceptional Research Opportunity. He worked in the laboratory of Eva Nogales at the University of California, Berkeley, investigating cytoskeleton assembly using electron microscopy and biochemical assays.

**Carmen Gacchina** (a doctoral student) received a summer internship at the National Institute on Aging (NIA) in the National Institutes of Health. Gacchina is completing her third year in the CU-MUSC bioengineering program in Charleston where she is a member of Anand Ramamurthi's laboratory team working on tissue engineering approaches to cardiac diseases. At the NIA, she worked with Mark Talan, a lead researcher in the cardiovascular science laboratory, for 10 to 12 weeks this past summer.

**Erin Pardue** (doctoral student) has been selected as a Presidential Scholar for the 2009-10 term at MUSC. Pardue is completing her third year in the CU-MUSC bioengineering program in Charleston, and her research is focused on cardiovascular tissue engineering in Scott Argraves' laboratory. The Presidential Scholars Program is a yearlong experience aimed at enriching the academic environment by facilitating interdisciplinary interaction on a broad range of issues that transcend scientific disciplines and professional boundaries.

# Biosystems Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 16

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 47 |
| | Master's | 13 |
| | Doctoral | 7 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 21 |
| | Master's | 3 |
| | Doctoral | 2 |

**Research expenditures:** $460,041

**Research thrusts:** water quality, bioprocessing, non-point-source pollution, instrumentation and control, bioseparations, aquaculture, machine design for biosystems engineering

**Justin Montanti** conducts research in Professor **Caye Drapcho's** lab on algae to produce high-value oils for use in pharmaceuticals or as biodiesel for fuel.

## Research Interests

Clemson's biosystems engineering program is focused primarily on three areas of research that when combined:

- create alternative bioproducts and energies (biofuels),
- protect our water and environment, and
- increase the productivity and profitability of agriculture without harming the environment.

## Bioprocessing/Applied Biotechnology

Clemson researchers are developing ways to improve the biological production of nutraceuticals and pharmaceutical compounds in addition to creating biomaterials and biofuels using natural and modified microorganisms. Biofuels, particularly biodiesel, made from biomass and aquatic organisms is currently a topic of significant research. Ongoing investigation also includes the study of hydrogen from biomass via fermentation pathways and electrical energy from microbial fuel cells. A recent $800,000 grant will purchase research equipment to study the derivation of ethanol from cellulosics (switchgrass, sorghum and wood residues). A $14 million pilot plant is being planned in Charleston.

## Natural Resources/Environment

Water management and water quality are major thrusts. Clemson researchers are focused on nearly every aspect of keeping water (surface runoff as well as ground water) safe from chemical or biological pollutants, wastewater treatment, land use and low-impact development, best management practices for erosion and storm-water control, watershed modeling to provide predictive models, bacteria modeling (the single most important cause of water impairment in South Carolina) and population dynamics in waterways and aquatic environments.

## Agriculture

Growing healthier, hardier crops and maintaining livestock herds with low environmental impact have become complex science. Research in this department includes:

- precision agriculture technology to increase productivity and profitability of crops while minimizing environmental impacts,
- site-specific control of crop insects and diseases,
- irrigation design and control, especially as implemented for sensor-based agricultural methods, and
- livestock waste management and alternate uses of wastes, such as energy production.

## Facilities

Biosystems engineering has several research facilities, including a fiber-quality lab, an agricultural/chemical/biological lab, aquaculture facilities and a biotechnology analytical lab. Facilities are located on campus in McAdams Hall, the Biosystems Research Complex and the Clemson Aquaculture Facility. Off-campus facilities include Edisto Research and Education Center (REC) near Blackville, Pee Dee REC near Florence and the Belle Baruch Institute of Coastal Ecology and Forest Science near Georgetown.

## New Faculty

The biosystems engineering department has 15 faculty members. **Anand Jayakaran**, from The Ohio State University, recently joined the team. His research includes watershed modeling, low-impact storm-water management and developing broad-based research initiatives that examine the impacts of development on the hydrology of coastal plains watersheds. His research focuses on how hydrologic and sedimentologic regimes are impacted by land development in coastal plain watersheds. With increased demands on the South Carolina coast, the need for low-impact strategies in the development of land is significant. Jayakaran conducted doctoral and postdoctoral research on low gradient modified stream systems in the agricultural Midwest. His graduate research contributed in part to the adoption of alternative stream management techniques in Ohio. Jayakaran has a strong interest in understanding the fluvial geomorphology of coastal streams and incorporating natural channel design in managing storm-water channels.

The latest faculty addition is **Hamid J. Farahani**, who comes from Colorado and Aleppo, Syria, where he was employed by the International Center for Agricultural Research in the Dry Areas. Farahani will conduct research at the Edisto REC where he will bring irrigation expertise to the sensor-based agriculture program that is developing there. One of the leading programs of its type in the world, Edisto REC seeks to develop and utilize cutting-edge engineering technologies to optimize agricultural production and sustainability by maximizing profitability while minimizing negative environmental impacts.

# Chemical and Biomolecular Engineering

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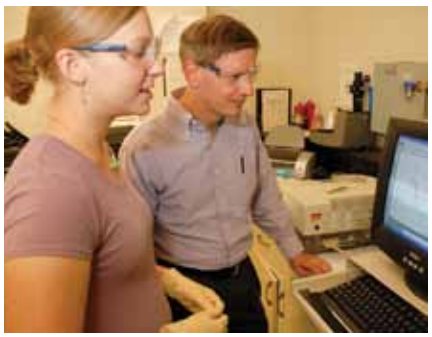
## Fast Facts

**Tenured/tenure-track faculty:** 10

| | | |
|---|---|---|
| **Enrollment**: | Undergraduate | 131 |
| | Master's | 1 |
| | Doctoral | 34 |
| **Degrees awarded (August and December 2008 and May 2009)**: | Undergraduate | 35 |
| | Master's | 1 |
| | Doctoral | 3 |

**Research expenditures:** $5,015,083

**Research thrusts:** chemical and biosensor devices, separation methods to recover products produced biologically by fermentation, thermochemical hydrogen cycles for fuel cells, molecular design of advanced carbon materials, synthesis of alternative fuels



Professor **Douglas Hirt** works with EUREKA! student **Courtney Taylor**. Hirt has been elected as a Fellow of the Society of Plastic Engineers.

## Departmental Overview

The Department of Chemical and Biomolecular Engineering allows students to specialize in many different research areas such as advanced materials — including polymers, energy, biotechnology and chemical processing. Strong departmental research programs exist in biosensors, polymer processing, rheology, fiber and film formation, supercritical fluids, separation processes, kinetics and catalysis, and membrane applications. The research activities of these groups cover most of the traditional branches of chemical engineering as well as several of the newer areas, including advanced materials, bioseparations, biofuels, hydrogen from water, fuel cells and molecular simulation. Research interests of the faculty range from purely theoretical topics to the analysis and improvement of full-scale industrial processes.

## Faculty Highlights

**Anthony Guiseppi-Elie**, director of the Clemson University Center for Bioelectronics, Biosensors and Biochips, and **Guigen Zhang**, deputy director of the Clemson University Institute for Biological Interfaces of Engineering, were invited presenters at the Institute for Biological Engineering (IBE) conference. Along with their students and postdocs, the Clemson delegation presented a total of 10 scientific papers on topics ranging from nanostructure-enhanced biosensors to implantable biomedical devices through polymeric hydrogels. Zhang has recently been elected a counselor-at-large of the IBE society.

**Douglas Hirt**, professor of chemical and biomolecular engineering and director of the Center for Advanced Engineering Fibers and Films, was elected as a Fellow of the Society of Plastics Engineers (SPE). He joins a group of only 268 members (about 1 percent of SPE membership) who have been selected for this prestigious honor. Hirt was recognized for his work on additive technologies that modify surfaces of polymeric fibers and films, and more recently, on the development of functional biomaterials.

**David Bruce**, associate professor of chemical and biomolecular engineering, has been named the modeling coordinator for the International Center on Catalysis for Energy Applications that is funded by the Department of Energy (DOE). This center is one of 46 new Energy Frontier Research Centers funded by DOE, and it has a total budget of $12.5 million over five years. Bruce's portion of the grant is $829,000, which will enable his modeling group to conduct quantum simulations of reactions. **James G. Goodwin Jr.** will also perform research for the center along with scientists and engineers from many other universities.

## Student Achievement

Senior **Alaina Floyd** has been awarded an NSF Graduate Research Fellowship to be used toward her graduate studies in chemical engineering. NSF awards approximately 900-1,600 graduate fellowships each year, depending on availability of funds. The fellowship provides three years of support for graduate study leading to a research-based master's or doctoral degree.

**Jennifer Moffit**, a sophomore from Spartanburg, S.C., has been awarded the prestigious Barry M. Goldwater Scholarship for Excellence in Science, Mathematics and Engineering. The scholarship program honoring Sen. Barry M. Goldwater was designed to foster and encourage outstanding students to pursue careers in the fields of mathematics, the natural sciences and engineering. The Goldwater Scholarship is the premier undergraduate award of its type in these fields.

# Chemistry

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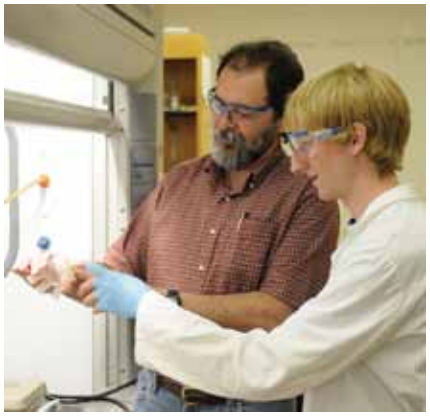
## Fast Facts

**Tenured/tenure-track faculty:** 23

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 118 |
| | Master's | 4 |
| | Doctoral | 90 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 19 |
| | Master's | 2 |
| | Doctoral | 19 |

**Research expenditures:** $4,860,136

**Research thrusts:** analytical, inorganic, organic and physical chemistry; interdisciplinary and nontraditional areas including polymer and materials, solid-state, bioanalytical, bioorganic and medicinal, and computational chemistry; chemical physics and chemical education



Professor **Bill Pennington** and recent graduate **Chris Pollock** work together in the lab. Chris started working in Pennington's lab as a freshman and is the winner of the Norris Medal.

## Department Overview

The chemistry department is one of the largest and most active academic programs on the Clemson campus. More than 20 faculty members direct the research of approximately 100 graduate students with the assistance of about 15 postdoctoral and visiting scientists. In addition, several faculty members are primarily engaged in undergraduate instruction, including direction of undergraduate research. Faculty also manage the department's Nuclear Magnetic Resonance Resource Center, Molecular Structure Center and additional computing resources.

The research activities of the faculty include projects in the traditional areas of analytical, inorganic, organic and physical chemistry as well as a broad range of interdisciplinary and nontraditional areas — polymer and materials chemistry, solid-state chemistry, bioanalytical chemistry, bioorganic and medicinal chemistry, computational chemistry, chemical physics, chemical education and other areas.

## Faculty Highlights

**Dennis Smith** has received the 2009 Governor's Award for Excellence in Scientific Research. The award was established in 1985 by the S.C. Drug Science Foundation to honor individuals or teams whose achievements and contributions to science merit special recognition and promote wider awareness of the quality and extent of scientific activity in South Carolina.

**Bill Pennington** has been recognized by his peers and the Class of 1939 as one of Clemson University's best faculty. The Class of 1939 Award for Excellence was established to recognize faculty members who contribute the highest levels of service to the student body, the University and the community. The recipient also becomes an honorary member of the class.

Pennington's research is focused on solid-state chemistry and depends heavily on X-ray crystallography, a technique used to probe the structure of matter at the atomic level. His research is important in areas such as pharmaceuticals.

**Rhett C. Smith** has won a CAREER award, the NSF's most prestigious research support program for the early career-development activities of teacher-scholars. Smith's research is directed to developing polymer materials that can conduct electricity. Traditionally, plastics are found more in structural contexts rather than as the active component of electronic devices. However, this relatively new class of electricity-conducting polymers can be used in thin, lightweight, flexible plastic electronic devices. Some of the most exciting applications are ultrathin materials that could be used to create flexible displays like television and computer screens or handheld electronic devices. Another exciting application that could have a bigger impact on society is thin-film solar cells to harvest energy from the sun as a renewable, potentially cheaper alternative to petroleum and coal-based energy sources.

## Student Achievement

The Norris Medal was awarded to **Christopher Pollock** of Allentown, Pa., who recently received his degree in chemistry. The medal is given each year to the graduating student who is judged to be the best all-around by the University Scholarships and Awards Committee. Pollock is a Goldwater Scholar and a member of Dixon Fellows. He is attending Cornell University to pursue his Ph.D. in inorganic chemistry.

## Facilities

A major renovation is planned for Hunter Hall, the current home of the chemistry department. The renovation will provide space to house high-end instrumentation facilities, including NMR spectroscopy, X-ray crystallography, optical spectroscopy and mass spectrometry.

# Civil Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 19

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 429 |
| | Master's | 48 |
| | Doctoral | 23 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 108 |
| | Master's | 30 |
| | Doctoral | 6 |

**Research expenditures:** $2,143,199

**Research thrusts:** applied fluid mechanics, construction engineering and management, construction materials, geotechnical engineering, structural engineering and transportation systems

Professor **Leidy Klotz's** research is in sustainable construction engineering. He works with the Resilient Homes Program, part of the Southeastern Region Research Initiative, a Department of Homeland Security Program managed by the Savannah River National Laboratory.

## Faculty Highlights

**Nadim Aziz** and **Abdul Khan**, in collaboration with Maria Mayorga in the industrial engineering department, are conducting research to evaluate relevant water resource planning, management (including operation) and legal issues related to the Savannah River Basin.

**Leidy Klotz** has received research funding for the Retrofit Techniques portion of the Resilient Homes Program. Klotz is also exploring behavioral influences on engineers' energy decisions, sustainability in engineering education and sustainable restoration of the built environment.

**Prasad Rangaraju's** research into the durability of concrete materials is gaining resurgence not only because of new issues that have surfaced in recent years, but the need to prolong and extend the serviceable life of concrete structures.

Graduate student **Hossein Hayati** and associate professor **Ronald Andrus** recently completed a liquefaction potential map of the peninsula of Charleston. Funding to develop the map was provided by the U.S. Geological Survey. The map appeared in the June 2008 issue of ASCE's *Journal of Geotechnical and Geoenvironmental Engineering*.

**Jim Burati** is continuing his research into specification development for highway construction and materials. This includes methods to evaluate the performance of both existing and proposed specifications. He recently completed a project for the Federal Highway Administration that resulted in new software for use in various data tracking and analysis functions for highway agencies and contractors.

**Wayne Sarasu** and researchers from the electrical and civil engineering departments are collaborating to develop computer vision algorithms for automatically monitoring traffic parameters from video input. These parameters include traffic counts, speed and vehicle classification data — which are fundamental to a variety of transportation projects ranging from transportation planning to modern intelligent transportation systems.

**Brad Putman** has been conducting research on sustainable materials. Of particular interest is his study of the sound absorption capacity of porous asphalt mixtures to reduce the noise generated from traffic passing over a pavement. This could have great implications in urban environments where residential communities are situated near highways.

**Nigel Kaye** is working on urban fluid mechanics, specifically air quality, pollution dispersion modeling and damage to structures during severe weather events.

**Jennifer Ogle** has conducted several research projects dealing with transportation infrastructure safety and management. She has recently completed an analysis of new safety assessment methodologies for ranking priority safety sites for the Georgia Department of Transportation. Most of her research involves high-tech vehicle instrumentation, driving simulation, 3-D virtual world development, and extensive data collection and mining.

**Steve Sanders** is collaborating with colleagues in industrial engineering to discover how to improve the cost, quality, scheduling and safety performance of the construction industry by applying selected industrial engineering fundamentals to construction projects.

**Russell Brown** received the Gilbert C. Robinson Award from the American Society for Testing and Materials.

## Student Achievement

Graduate students **Priyanka Alluri, Lee Tupper** and **Katrina Bartman** received the prestigious Dwight D. Eisenhower Fellowship, funded by the U.S. Department of Transportation.

Alumna **Suzanne Aultman** was named the 2009 National Society of Professional Engineers Young Engineer of the Year. Suzanne is a chief engineer with Metromont in Atlanta, Ga.

# School of Computing

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## Fast Facts

**Tenured/tenure-track faculty:** 29

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 284 |
| | Master's | 89 |
| | Doctoral | 42 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 34 |
| | Master's | 26 |
| | Doctoral | 2 |

**Research expenditures:** $710,684

**Research thrusts:** *Division of Computer Science:* algorithmic foundations, software engineering, cyberinfrastructure, high-performance computing; *Division of Visual Computing:* graphics, visualization, vision, animation; *Division of Human-Centered Computing:* human-computer interaction, computing education, user-interface design

Professor **Juan Gilbert** is the new chair of human-centered computing. His research includes the most accessible electronic voting interface ever created.

## Department Overview

Clemson's School of Computing was formed from the Department of Computer Science in 2007 with a vision to be a national leader in the definition and advancement of emerging academic fields in computing through the development of successful divisions that integrate computation with the arts, sciences and engineering. The School of Computing is key to the College of Engineering and Science's mission of preparing students for all aspects of computing and as part of a University-wide emphasis on information technology and high performance computing. Providing a diverse and rich educational environment in many areas of computing, it also maintains nationally prominent research programs in selected focus areas. The school was reorganized in fall 2008 into three primary academic divisions: computer science, visual computing and human-centered computing.

- Computer science offers students the opportunity for classroom study and research in the underlying theory of computation, algorithms, software engineering, cyberinfrastructure, computer systems and other core areas of traditional computer science.
- Visual computing offers students the opportunity for classroom study and research in computer graphics, visualization, computer vision and image processing, and in various electronic arts such as game design, special effects and animation.
- Human-centered computing (HCC) is the newest division. HCC is an emerging field focused on understanding how to make computational technologies more useable and how computational technologies affect society.

The school currently has 275 undergraduate students and 135 graduate students enrolled in programs leading to the B.A., B.S., M.S. and Ph.D. in computer science; B.S. in computer information systems; and M.F.A. in digital production arts.

## Facilities

The School of Computing is housed in McAdams Hall, which recently underwent a $3.9 million renovation and expansion. The project renovated 20,000 square feet of space and added another 24,000 square feet of space. Students have 24-hour access to a diverse set of school facilities that range from workstations, graphics systems, virtual reality systems, networking labs, video production equipment, motion capture and computer clusters.

## Faculty Highlights

**Brian Dean** has been awarded an NSF CAREER grant to research and develop more efficient algorithms for a wide range of computational problems. The grant — totaling $400,000 — will fund Dean's project, "CAREER: Algorithmic Aspects of Ordinal Matching Problems."

Dean's research will focus on a class of computational problems known as matching problems, such as assigning students to classes, directing traffic to Web servers or matching donor kidneys between families participating in an organ-exchange network. His goal is to develop simpler and more efficient algorithms for computing solutions to these problems in which most of the participants are assigned to one of their highest-preferred alternatives.

**Juan E. Gilbert** has been named the new chair of human-centered computing in the School of Computing. He has research projects in spoken language systems, advanced learning technologies, usability and accessibility, ethnocomputing (culturally relevant computing) and databases/data mining. His research in electronic voting has resulted in the most accessible voting system interface ever created, while his data mining and user interface research has created Applications Quest, an analysis tool that allows admissions officers to address diversity in admissions while adhering to all judicial decisions on the matter.

**Larry Hodges** and **Andrew Duchowski** received a three-year Research Experiences for Undergraduates site grant from the NSF. The Undergraduate Research in Human-Centered Computing Summer program will provide research experience to undergraduate students from populations that are underrepresented in computing by immersing each student into the activities and culture of a research lab.

## Student Achievement

**Zachary Jones**, a third-year doctoral student, has been awarded an IBM Ph.D. Fellowship for the 2009-2010 academic year. The award, which covers tuition and mandatory fees, also comes with a $17,500 stipend.

Jones' research is in the areas of systems and virtualization and focuses on creating a virtual PCI device framework for the development and design of device drivers. This framework allows for a virtual device to be used in lieu of a physical device for designing and implementing device drivers. His adviser is **Robert Geist**.

# Electrical and Computer Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 31

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 360 |
| | Master's | 84 |
| | Doctoral | 53 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 83 |
| | Master's | 34 |
| | Doctoral | 3 |

**Research expenditures:** $2,385,915
**Research thrusts:** wireless communications, computer networks, nanoelectronic materials processing, bio chips, semiconductor lasers, integrated circuit design, high-performance computing, computer security, robotics, image processing, biological modeling, situation and threat assessment, power systems

Professor **Xiao-Bang Xu** has been awarded an NSF grant to study the electromagnetic scattering of 3-D objects buried in stratified earth. The grant resulted from a proposal to the Electrical, Communications and Cyber Systems division of the NSF.

## Department Overview

Clemson University has maintained a traditionally rich background in fundamental and applied engineering as research areas have focused onto increasingly narrower topics within the subject disciplines. This heritage provides the Department of Electrical and Computer Engineering (ECE) with the breadth to offer a sound undergraduate education. At the same time, the specialization of faculty provides the stimulating environment for research.

ECE offers two separate degree program areas: electrical engineering and computer engineering. As one of the larger departments on campus, ECE plays a major role in degree production, sponsored research activity and service to the community.

The graduate programs offer a variety of opportunities for development through research, specialized formal course work and teaching experience. The department offers the M.Engr., M.S. and Ph.D. degrees in both electrical engineering and computer engineering.

## Faculty

More than 40 ECE faculty members teach and perform research in a broad range of topics, and many are known nationally and internationally. Among them are IEEE Fellows, two endowed chairs and seven named professors. Additionally, several young faculty members have won prestigious national and international awards and grants.

## Facilities

The department occupies more than 20,000 square feet of research space with approximately 9,000 square feet located in the state-of-the-art Fluor Daniel Engineering Innovation Building.

CoES is well-equipped with networked workstations and personal computers that serve as the foundation for course computing needs as well as the backbone of computing support for the research programs. In addition, a variety of workstations and dedicated computers are maintained in various research laboratories throughout the ECE department.

## Faculty Highlights

ECE welcomes three new faculty who have come to the department through joint academic appointments with their home departments. **Jill Gemmill, Barr von Oehsen** and **David White** are part of Clemson's Cyberinfrastructure Technology Integration (CITI) group, which provides cyberinfrastructure resources and high-performance computing capabilities to the campus.

**Michael Pursley**, holder of the Milton and Betty Holcombe Endowed Chair in Electrical and Computer Engineering, has been awarded basic research grants totaling approximately $620,000 from the Army Research Office and the Office of Naval Research to support long-term basic study of cognitive radio and dynamic spectrum access communications. Additional support for the research is being provided by the Lincoln Laboratory at MIT. Assisting in the research are Clemson graduate students Steven Boyd, Jason Ellis, Michael Frye and Michael Masse. Thomas Royster of the Lincoln Laboratory is also collaborating with the Clemson team.

## Student Achievement

Junior **Michael Juang** was one of three Clemson students who earned the prestigious Barry M. Goldwater Scholarship for Excellence in Science, Mathematics and Engineering this year. The scholarship program was designed to foster and encourage outstanding students to pursue careers in the fields of mathematics, engineering and the natural sciences.

Computer engineering junior **Bradley Collins** was awarded a Tau Beta Pi scholarship. Recipients are competitively selected on the basis of high scholarship, campus leadership and service, and promise of future contributions to the engineering profession.

# Engineering and Science Education

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## Fast Facts

**Tenured/tenure-track faculty:** 7

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 1,130 |
| | Master's | 33 seeking certificates |
| | Doctoral | n/a |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | n/a |
| | Master's | n/a |
| | Doctoral | n/a |

**Research expenditures:** $234,005
**Research thrusts:** epistemologies, learning mechanisms and systems, diversity and inclusiveness, assessment

Professor **Julie Trenor** will serve Women in Engineering ProActive Network (WEPAN) in a three-year term as president-elect, president and past president. WEPAN is the nation's leading organization and catalyst for transforming culture in engineering education to promote the success of all women. It includes more than 600 members from nearly 200 engineering schools, small businesses to Fortune 500 corporations, and nonprofit organizations.

## Department Overview

The Department of Engineering and Science Education (ESE), instituted in 2006, is unique in that there is no other department like it in the United States. It offers CoES graduate students the opportunity to earn a certificate in engineering and science education and is designed to offer experience in preparation for an academic career. The program is also ideal for those who wish to further their understanding of the education process in engineering and science, or who are interested in engineering and science education research. This certificate program specifies a range of courses (minimum of 11 credits) that may be selected to address specific research questions or interests.

ESE faculty include:

**Julie Trenor** – Research focuses include academic and career choice processes of underrepresented students in engineering (including women, minorities and first-generation college students), students' use of social capital in making academic and career decisions about engineering, and family roles in students' engineering academic and career decisions.

**Lisa Benson** – Research interests include student-centered active learning in undergraduate engineering, assessment of motivation and how motivation affects student learning. Benson is also involved in projects that utilize Tablet PCs to enhance student learning.

**Zahra Hazari** – Interests include curriculum choices that stimulate physical science identity development in a culture of testing and gender bias in students' ratings of their science teachers.

**Geoffrey Potvin** – Working on female representation in STEM disciplines and the recruitment and retention of physical scientists. This is connected to the relative decline in interest and completion of bachelor's degrees in physics and chemistry.

**Melanie Cooper** – Interested in the development and assessment of curriculum materials; interventions designed to improve conceptual understanding, problem solving and metacognition; and use of technology to improve learning outcomes.

## Faculty Highlights

**Zahra Hazari** won Best Paper (with Marisa Orr, Philip Sadler and Gerhard Sonnert) in the Education Research and Methods Division at the American Society for Engineering Education Conference in 2009.

**Lisa Benson** has four papers accepted for presentation at the 2009 ASEE conference in addition to a paper and workshop accepted for presentation at the 2009 Frontiers in Education conference. She was the recipient of the 2008 Helen Plants Award for the Best Nontraditional Session at the 2008 Frontiers in Education Conference for her workshop, "Enhancing Student Learning Using the SCALE-UP Format."

**Melanie Cooper** organized and presented a symposium at the 2009 AAAS meeting. She also organized the award symposium for Chemical Education Research at the 2009 ACS meeting and was an invited speaker at the 2009 Gordon Research conference.

**Julie Trenor** is currently the president of the Women in Engineering ProActive Network.

## Student Achievement

**Lisa Benson** is currently advising a Creative Inquiry team that designed an entry for the Walt Disney ImagiNations Competition, sponsored by Walt Disney Imagineering. The team's submission was selected as a semifinalist in this year's competition (top 40 percent of all entries).

**Charity Watson**, working with **Zahara Hazari**, won a Predoctoral Research Fellowship from Harvard Smithsonian Center for Astrophysics.

**Sonia Underwood** and **Alma Gonzale**s, working with **Melanie Cooper**, were accepted to the first graduate student conference on chemical education research.

# Environmental Engineering and Earth Sciences

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## Fast Facts

**Tenured/tenure-track faculty:** 18

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 34 |
| | Master's | 48 |
| | Doctoral | 24 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 9 |
| | Master's | 12 |
| | Doctoral | 4 |

**Research expenditures:** $1,867,823

**Research thrusts:** environmental chemistry, environmental fate and transport, hydrogeology, nuclear environmental engineering and science, process engineering, sustainable systems and environmental assessment

Professor **Cindy Lee** received an NSF award to study the use of chiral tracers to determine cycling of POP's in stream ecosystems. Lee has also been selected as an editor of *Environmental Toxicology and Chemistry* for environmental chemistry. The publication is one of the official journals of the Society of Environmental Toxicology and Chemistry.

## Department Overview

The Department of Environmental Engineering and Earth Science (EEES) has a synergistic blend of environmental engineering and science, geology and earth science, and nuclear environmental engineering and science. We offer several academic options to our students.

At the undergraduate level, the department is committed to providing the next generation of earth scientists a comprehensive understanding of earth processes through our B.A. and B.S. degrees in geology. Specialization tracks in traditional geology, environmental science and hydrogeology allow students to focus their course work in areas of their particular interest. Unique to Clemson, all of our undergraduate geology students participate in research with a faculty member from sophomore through senior years.

At the graduate level, the department has two distinct programs: environmental engineering and science (EE&S) and hydrogeology. The EE&S program offers M.S., M.Engr. and Ph.D. degrees, while the hydrogeology program offers an M.S. degree. Both programs are nationally recognized and have been continuously ranked in the top 25 programs by *U.S.News & World Report*.

Overall, the diverse, dynamic and talented faculty and rich curriculum of EEES provide a rich, scholarly and challenging educational experience to our students.

## Faculty Highlights

**Shelie Miller** received an NSF CAREER award for her project entitled "Creation of Predictive and Dynamic Life Cycle Assessment Tool." This is the most prestigious NSF award that supports junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education, and the integration of education and research within the context of the mission of their organizations.

**Larry Murdoch** was voted onto the executive committee of the board of directors of CUAHSI (Consortium of Universities for the Advancement of Hydrologic Sciences Inc.). CUAHSI has more than 100 member universities and is an important voice in the hydrologic community.

**Jim Castle** and John Rodgers, a professor in Clemson's forestry and natural resources department, were recently awarded more than $800,000 to find economical and environmentally sensible ways to treat water that comes out of the ground during oil and natural gas production. Funding is from the U.S. Department of Energy and Chevron of Houston, Texas. Castle and Rodgers are developing constructed wetland systems to treat the contaminated water for reuse.

**David Freedman** was awarded the 2008 Association of Environmental Engineering and Science Professors (AEESP) Outstanding Publication Award for his paper entitled "Biological reductive dechlorination of tetrachloroethylene to ethylene under methanogenic conditions." This very prestigious recognition by AEESP is given annually to recognize the author(s) of a "landmark environmental engineering and science paper that has withstood the test of time and significantly influenced the practice of environmental engineering and science."

## Student Achievement

**Jesse Addison's** master's thesis, "The formation of halonitomethanes in wastewater treatment plant effluents," was selected to receive the American Water Works Association's (AWWA) second place 2009 Academic Achievement Award for the Best Master Thesis. Each year AWWA recognizes two M.S. and two Ph.D. theses in its nationwide competition. **Tanju Karanfil** served as Jesse's adviser.

**Dave Hisz** won the Outstanding Student Paper Award (Hydrology Section) for his presentation entitled "Hydromechanical responses in dipping fractured mudstones at the NAWC site, West Trenton, N.J." at the 2008 Fall Meeting of the American Geophysical Union in San Francisco. **Larry Murdoch** serves as Dave's adviser.

**Darryl B. Jones** was selected by AWWA as its 2009 LARS Ph.D. Fellowship recipient. Every year, AWWA gives one award to a candidate for M.Sc. ($5,000 one-time funding) and one for Ph.D. ($7,500 one-time funding) after its nationwide competition. **Tanju Karanfil** serves as Darryl's adviser.

# Industrial Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 11

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 140 |
| | Master's | 100 |
| | Doctoral | 32 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 42 |
| | Master's | 16 |
| | Doctoral | 4 |

**Research expenditures:** $777,605
**Research thrusts:** supply chain, optimization and logistics; human factors and safety in complex systems; education and learning systems

Professor **Sandra Garrett** and her students work with a local hospital to improve workflow.

## Department Overview

The Department of Industrial Engineering offers three separate degrees: B.S., M.S. and Ph.D. In addition, in the beginning of 2009, the industrial engineering program unveiled an online M. Engr. in industrial engineering focused on capital projects supply chain.

## Faculty Highlights

The department takes great pride in the work faculty have done to promote excellence in scholarship, research and industrial engineering education. In the last four years, the department has recruited faculty from top industrial engineering programs, bringing a wealth of new ideas and talent to the department. This synergy is exemplified by several initiatives currently under way.

**Byung Rae Cho** is leading a department-wide six-sigma and quality research and educational effort.

The department has been selected as an NSF site for the Center for Engineering Logistics and Distribution. As part of this center, **William G. Ferrell**, **Mary Elizabeth Kurz**, **Scott A. Shappell** and **Kevin M. Taaffe** are pursuing systems integration-, hurricane evacuation-, logistics- and optimization-related research with federal and state agencies and several regional and upstate companies.

In the human factors area, **Joel S. Greenstein**, **Sandra K. Garrett, Scott A. Shappell** and **Paris F. Stringfellow** are actively pursuing funded research in systems safety, human error, human computer interaction, learning technologies and job aiding.

To engage undergraduate students in research, **Maria E. Mayorga** and **Brian J. Melloy** have proposed a new Creative Inquiry paradigm to enrich student experience at Clemson University.

**Sandra Garrett** is working with Barrett Caldwell of Purdue University to propose a new system that warns of an impending pandemic by monitoring signals in human behavior. The system could result in using a simple icon on a television screen to warn of future phases of an outbreak of an illness such as the flu. Researchers agree it is extremely difficult to identify a pandemic event before it is under way and spreading from person to person, yet the timeliness of this early detection is critical for an effective response and disaster-mitigation strategy. History and computer-generated simulations show that the speed in which a response strategy is initiated — even more than the specific strategy itself — will have the largest influence in reducing the overall impact of a pandemic. Given the importance of rapid response, identifying the specific event phases and the triggers that indicate a need for action is essential.

## Student Achievement

At the Summit on the NAE Grand Challenges held at Duke University last spring, **Thashika D. Rupasinghe** and **Deepak Vembar** (Advanced Technology Systems Laboratory) won first place in the Learning/Computation Poster competition. They received this award for their research poster entitled "Virtual reality in aircraft maintenance technology." The Grand Challenges are a critical grouping of problems that must be addressed and solved in order to maintain our national security, quality of life and sustainable future.

# School of Materials Science and Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 17

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 115 |
| | Master's | 11 |
| | Doctoral | 52 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 32 |
| | Master's | 3 |
| | Doctoral | 6 |

**Research expenditures:** $6,500,590

**Research thrusts:** processing and applications of novel inorganic, organic and natural fibers; processing and characterization of interfaces: chemistry, microstructure and failure and fatigue attributes; high-performance metal alloys and metal-, glass- and polymer-based composites; structural and optical ceramics and glasses

The Advanced Materials Research Laboratory is home to both COMSET and the University's Electron Microscope facility.

## Department Overview

Research in the School of Materials Science and Engineering (MSE) is as diverse as its faculty interests. Faculty in MSE conduct research on ceramics, glasses, polymers, photonics, medical textiles, biomaterials, fiber science, thin films and metallurgy.

The department is comprised of expert collaborators who work with nearly every department in CES and across colleges as their support of numerous University centers and institutes demonstrates. Their ability to create stronger, lighter and more efficient materials makes MSE researchers attractive research partners with broad design, process, characterization and manufacturing experience.

Clemson's School of Materials Science and Engineering is one of a small group of MSE programs in the country where faculty and students not only work with, but actually make, many of the materials they design and test — from optical glass and fibers to bricks, bio-polymer fiber scaffolds, space fabrics and nanograined metallic materials. While computational materials science is also employed in the design and evaluation of materials in systems, the school also provides a sound foundation in the study of chemistry, structure and property relationships. Hands-on experience of realizing fundamental principles of science and engineering is taught through laboratory training. Such balance of class and lab focus is a key part of the Clemson MSE curriculum.

## Student Achievement

**Alexandra (Ali) Foguth** was selected for a 2008 NSF Graduate Research Fellowship. This prestigious and highly competitive award provides three years of support for master's or doctoral students who excel in disciplines relevant to the NSF mission. This award grants funding of $44,550 per year for the selected student. Ali is the second student from the School of Materials Science and Engineering to receive this award.

## Facilities

The school and its faculty participate in the following Clemson research centers:

- The Center for Optical Materials Science and Engineering Technologies (COMSET) is headquartered at the Advanced Materials Research Laboratory, a $21 million complex in the Clemson University Advanced Materials Center. The 111,000-square-foot research facility houses laser and chemical labs and the University's Electron Microscope (EM) facility. COMSET is recognized as a global leader for innovation and education in the science and technology of optical materials. Since it began in 2000, it has garnered more than $40 million in research funding.
- The director of the University's EM facility, **JoAn Hudson**, holds a research faculty appointment in MSE. One of the most outstanding EM facilities in the country, this is a critical resource to MSE team members and other researchers.
- Clemson Apparel Research (CAR) was established to revitalize the domestic sewn-products industry through the application of advanced technology and management practices. It is now a premier national resource for high-performance textiles and related materials research and applications. CAR's fast-turn manufacturing and supply chain optimization solutions are being applied to other industries.
- The Clemson Conservation Center focuses on the science of conserving and preserving archeological finds and other historic treasures. One of their current projects is the conservation of the *H.L. Hunley*, a Civil War submarine that sat at the ocean floor for 130 years before it was found and brought up.
- The National Brick Research Center is an industry-funded organization providing research, education and service to producers and users of clay bricks and other ceramic materials (tile, mortar and ceramics).

# Mathematical Sciences

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## Fast Facts

**Tenured/tenure-track faculty:** 43

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 107 |
| | Master's | 27 |
| | Doctoral | 76 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 17 |
| | Master's | 30 |
| | Doctoral | 10 |

**Research expenditures:** $1,202,724
**Research thrusts:** algebra/discrete mathematics, applied analysis, computing, operations research, probability/statistics

Mathematical science classes are held in 60 of Clemson's 250 smart classrooms interspersed around campus. These smart spaces enable the sharing of work to solve problems and foster collaboration. They also facilitate online quizzes — either in or out of class — and accommodate mathematical modeling.

## Department Overview

The Department of Mathematical Sciences provides major contributions to the instructional and research mission of the University. Enrollments average 5,000 to 6,000 students per semester in more than 300 sections of math sciences courses, ranging from beginning freshman to cutting-edge, graduate-level research courses. Mathematical instruction and research are led by more than 80 faculty members and 100 graduate students.

Prominent research activities include publications (more than 100 per year), invited presentations (30 or more national and international talks each of the past three years), national and international professional involvement of the faculty, and funded research worth approximately $1 million per year. Computational modeling, biomathematics and stochastic modeling have garnered recognition for the department.

Degree programs are organized by discipline into five areas in the mathematical sciences: algebra and discrete mathematics, applied analysis, computational mathematics, operations research, and probability and statistics.

## Faculty Highlights

The INFORMS Lanchester Prize for 2008 was awarded to **Warren P. Adams** for a series of papers, including "A hierarchy of relaxations leading to the convex hull representation for general discrete optimization problems," which was jointly published with Hanif D. Sherali.

**Taufiquar Khan** and **Irina Viktorova** lead an interdisciplinary research team in a joint effort with ITRON Inc., a leading technology provider and critical source of knowledge to the global energy and water industries. The team will be developing information theory and noise models for complex power system networks using mathematical techniques to increase efficiency and cut costs for an optimal "smart grid" network.

For the fifth consecutive year, the Department of Mathematical Sciences hosted the Clemson Calculus Challenge, a competition based on the advanced placement calculus AB syllabus. Recognized with $30,000 in NSF funding, the 2009 competition involved 227 of the region's brightest high school math students, covering areas of the Southeast with most students coming from Georgia, North Carolina and South Carolina. The Department of Mathematical Sciences is eager to encourage the study of calculus in high school; prizes of this annual competition include partial Clemson University scholarships.

## Student Achievement

**Steven Goodson, Mira Narayan** and **Josh McGinnis** — students from mathematical sciences' Creative Inquiry courses — presented research talks at the Undergraduate Research Conference at Francis Marion University in March 2009 and exhibited research posters during the research days at Clemson University in April 2009.

# Mechanical Engineering

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## Fast Facts

**Tenured/tenure-track faculty:** 33

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 521 |
| | Master's | 135 |
| | Doctoral | 71 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 124 |
| | Master's | 46 |
| | Doctoral | 7 |

**Research expenditures:** $2,993,414

**Research thrusts:** automotive engineering; bioengineering and biomaterials design; dynamics and controls; fluid mechanics; materials and materials processing; manufacturing; solid mechanics; thermodynamics, heat transfer and combustion

Professor **Joshua Summers** works with **Samantha Thoe** on the Tweel. He is part of the SAE 2009 Ralph R. Teetor Educational Award program.

## Department Overview

The Department of Mechanical Engineering has one of the largest academic programs in the state of South Carolina with 520 undergraduate students and 199 graduate students. The department has seen unprecedented growth in the last three years with 13 new faculty joining its ranks, the creation of a graduate program in automotive engineering that focuses on systems integration to meet the challenges of the global automotive marketplace, and the construction of a 90,000-square-foot, unique facility to house the new program.

Funded research activities put this department at the cutting edge in various fields. The research is distributed across nine major disciplines: automotive engineering, bioengineering and biomaterials, design, dynamics and controls, fluid mechanics, materials and materials processing, manufacturing, solid mechanics and thermodynamics, heat transfer and combustion.

Newly developed focus areas include lightweight engineering design for reduced energy consumption in automobiles, development of novel computational and experimental techniques to address fluid flow and combustion problems at different scales, development of new biomaterials and biomanufacturing processes, energy management using control and thermal management techniques, and dynamics, control and measurements in MEMS and NEMS. Computational research makes use of a supercomputing cluster to study microscale phenomena using atomic-level molecular dynamics simulations. These simulations have recently identified novel pathways by which buckyballs and other man-made nanoparticles may be able to enter human cells. The department is also the birthplace of materials formed by chaotic advection.

## Faculty Highlights

A multiple-year grant from the National Institutes of Health is allowing Clemson and Medical University of South Carolina (MUSC) researchers to explore the feasibility of using a motionless valve — known as a fluid diode — as a pulmonary heart valve replacement. **Richard Figliola**, Clemson professor of mechanical engineering and bioengineering, heads the study. **Tim McQuinn**, a pediatric cardiologist, and **T-Y Hsia**, a pediatric heart surgeon, lead the MUSC team. **Don Beasley** from Clemson's mechanical engineering department and **Naren Vyavahare** from bioengineering are co-investigators. Nearly a dozen undergraduate and graduate students have been involved in the research.

Fluid diodes allow flow to travel in a preferred direction based on their novel design. The valve design is such that it can be made from man-made or biological materials. To date, the experimental data has agreed with limited clinical results, and the research group is now collaborating with leading pediatric specialists in London and Milan to apply these specialized modeling techniques to other congenital heart defect problems.

**Joshua D. Summers** was selected for the Society of Automotive Engineers 2009 Ralph R. Teetor Educational Award program. This program recognizes outstanding educators and gives them the opportunity to complement their students' classroom and laboratory training with the perspective of current industry philosophy and trends. Summers' research interests focus on studying the mechanical engineering design process in order to develop enabling tools for designers. The research includes efforts in modeling the collaborative design process, developing geometric tools for archiving and retrieving 3-D knowledge, and developing CAD tools that may be migrated to virtual reality applications for designer benefit.

**Thomas R. Kurfess**, the BMW Endowed Chair in Manufacturing, has been named a Fellow of the American Association for Advancement of Science (AAAS). Election as a Fellow is an honor bestowed upon AAAS members by their peers. Kurfess was elected for distinguished contributions to the field of manufacturing systems and precision engineering, particularly advanced process development and quality control for global production systems.

Kurfess' research at the Clemson University International Center for Automotive Research focuses on advanced production systems, process control, and process diagnostics and prognostics to ensure vehicle performance. His work also extends to advanced vehicle stability and control.

## Student Achievement

**Matthew Torok** won a research award from the South Carolina Space Grant Consortium. This award will support the development and construction of high-altitude balloon measurements and experimentation to support ongoing NASA research.

**Luke Berglind** traveled to Seoul, South Korea, to represent his team in a capstone design fair competition. He brought home a medal and international accolades. His team's screw-feeding system project, sponsored by BMW, earned third place and was recognized as the best applicable project at the fair to have immediate impact in industry. Team members include **Christopher Martin, Nick Pillman** and **Ross Vickers**, and faculty advisers **Joshua D. Summers** and **Todd Schweisinger**.

**Beshoy Morkos** has been selected for the prestigious ASME Graduate Teaching Fellow Award. At any one time, only three of these fellowships are in place nationally. This marks the third Teaching Fellow in Clemson's mechanical engineering department since the inception of the program.

# Physics and Astronomy

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## Fast Facts

**Tenured/tenure-track faculty:** 23

| | | |
|---|---|---|
| **Enrollment:** | Undergraduate | 85 |
| | Master's | 6 |
| | Doctoral | 38 |
| **Degrees awarded (August and December 2008 and May 2009):** | Undergraduate | 12 |
| | Master's | 6 |
| | Doctoral | 4 |

**Research expenditures:** $2,904,970
**Research thrusts:** astrophysics, atmospheric and space, biophysics, materials, nanomaterials, surface and interface, nanoscience, single-molecule biophysics, solid state

Professor **Gerald Lehmacher** makes final preparations before payload assembly at Poker Flat Research Range, north of Fairbanks, Alaska.

## Department Overview

Classical physics encompasses the fields of mechanics, heat and thermodynamics, electricity and magnetism, acoustics and optics. Modern physics is concerned with the study of atoms and molecules, atomic nuclei, elementary particles and the properties of liquids, crystalline solids and other materials in addition to the nature of planets, stars, galaxies and the large-scale structure of the universe.

The undergraduate physics curricula are designed to provide students with a strong background in the classical areas of physics as well as introduce the more important aspects of modern physics. The B.S. in physics provides a good basis for graduate study or industrial work in areas such as engineering physics and applied science.

Graduate study in physics and astronomy for either the Ph.D. or M.S. degrees is a great opportunity for students who want

- to pursue a research career in physics, astronomy or closely related fields;
- to be expert teachers of these subjects; or
- to gain broad-based technical expertise for other careers.

Graduate students spend a good deal of their time engaged in forefront research, conducted under the mentorship of our world-class faculty. Most graduate students also teach physics and/or astronomy classes.

After graduation, our M.S. and Ph.D. recipients take diverse career paths. Some join faculty in research universities and teaching colleges. Others work in research positions at places such as national research laboratories, NASA, the Department of Energy, national observatories, and the U.S. Navy or Air Force. Graduates also work for numerous private companies in research and development or in management. Also, many of our international students return to positions such as these in their home countries.

## Faculty Highlights

NASA has awarded funding to Clemson astronomers led by **Mark Leising** to study a mysterious emission coming from the central regions of the Milky Way galaxy.

Gamma rays, the light of energy a thousand times more powerful than X-rays created by the convergence of antimatter and normal matter, are seen coming from the disk of our galaxy — roughly from where we see the glow of the Milky Way under a dark sky — but mostly from the direction of the center of the galaxy in the Southern Hemisphere.

"We're not surprised to see this emission from the Milky Way's disk," says Leising. "What is surprising is how bright this emission is from the center of the galaxy. It's not coming just from the very center — where a black hole lurks that is two million times the Sun's mass — but from a region a few thousand light-years across surrounding the center."

One explanation involves black holes — collapsed stars of five to 10 solar masses — pulling matter from close companion stars. Another involves the decay of exotic "dark matter" particles. Dark matter is the name given to something out there that is detected so far only by its gravitational pull on normal matter.

Leising and his students are working in collaboration with colleagues from Germany, France and NASA's Goddard Space Flight Center. They hope to unravel this mystery by combining information from a number of NASA and European Space Agency satellites.

Clemson space physicists led by **Gerald Lehmacher** have traveled around the world to launch rockets to test atmospheric conditions. Most recently, the scientists launched a salvo of four rockets over Alaska to study turbulence in the upper atmosphere. The launches took place at Poker Flat Research Range north of Fairbanks as part of a NASA sounding rocket campaign.

Lehmacher was assisted by graduate students **Shelton Simmons** and **Liyu Guo**.

The rockets were 35-foot, two-stage Terrier Orions, and they released trimethyl aluminum that created a glowing vapor trail nearly 87 miles up. Sensitive cameras on the ground tracked the trails. From that data, Lehmacher and his team were able to analyze upper-atmospheric winds by tracking how the vapor trails formed, billowed, dispersed and diffused. Two of the rockets had additional deployable payload with instrumentation to measure electron density and neutral temperature and turbulence.

In January, **Miguel Larsen** was assisted by three undergraduate students, **Lucas Hurd, Matt Jenkins** and **Matt Henderson**, in Norway to carry out a joint experiment with Japanese scientists to study atmospheric winds and circulation from heating created by electrical currents associated with the Northern Lights. The measurements were made with instruments flown on a Japanese S-310 rocket launched from the Andoya Rocket Range in northern Norway and a suite of sensitive radar and camera instruments on the ground.

Larsen was responsible for the wind measurement aboard the instrumented rocket.

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