SOUTH DAKOTA
SCHOOL OF MINES
& TECHNOLOGY

Electrical Engineering Department

1920 – 2020

Celebrating 100 Years of Excellence and Beyond

years


ELECTRICAL
ENGINEERING/PHYSICS
3rd Floor
Electrical & Computer Engineering
2nd Floor
Department of Physics
Nano Science & Engineering
1st Floor
Information Technology Services (ITS)

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I want to extend my congratulations to the Department of Electrical Engineering's faculty, staff, students, and alumni on the department's 100th anniversary!

I am very proud to say that I am a graduate of the electrical engineering program at SD Mines. The reputation of the school and the EE program has helped me throughout my career, both in industry and in academia.

As SD Mines EE graduates, we exited the university well prepared for the working world as well as graduate school. Our education allowed us to compete with colleagues from other universities, and often, to excel beyond them. As a component of the strong curriculum, EE graduates came away with a strong work ethic that led them to be successful in both technical and management fields.

One example is a personal story: to enter the graduate program at Iowa State, all prospective students had to pass a comprehensive exam. Of the dozen or more students who took the comprehensive exam with me, only two passed on the first try. Both of us had our BS EE degrees from the SD Mines!

It is important to point out the vital role that the EE faculty have played in our careers. The faculty and staff were always willing to help and answer questions. Many of the faculty had worked in industry at some point in their careers and brought that knowledge into the classroom. Some of the faculty who taught me are still associated with the university, while others have passed. No matter what the situation, they are still in my memory, and I am sure that you have strong memories as well.

I hope that alumni who are reading this celebratory tribute will strengthen their ties back to the department. It is our strong alumni network that will help new graduates as they transition into their careers.

Congratulations again to the Department of Electrical Engineering on their 100th anniversary. I look forward to seeing the great accomplishments the department will have in the future.

Best,

James Rankin

Jim Rankin
EE 1978
19th President, SD Mines

FACULTY-STAFF DIRECTORY

Faculty/Staff	Title	Education	Area of Expertise	Email
Dr. Thomas Montoya	Interim Department Head	PhD, Georgia Institute of Technology MS University of Colorado at Colorado Springs BS EE & BS Physics, SD Mines	Antennas, applied electromagnetics, ground penetrating radar	Thomas.Montoya@sdsmt.edu
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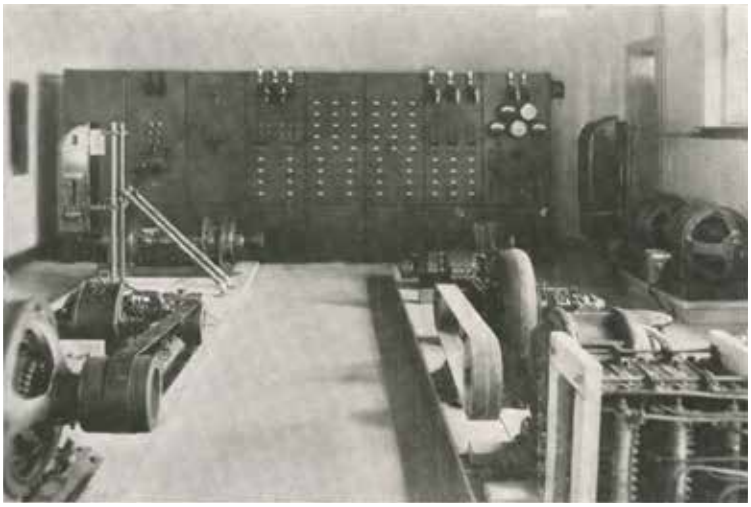
Department History

The Beginning: pre-1920



In 1913, the South Dakota Board of Regents (SD BoR) resolved, "That authority be granted the SD Mines to outline its course of study to the effect that students taking work to receive degrees already in vogue, should have the option of majoring either Electric [sic] or Civil Engineering." This process took six years to complete with a course of study in electrical engineering being offered at the Mines in 1919. Quite naturally, this program of study in electrical engineering centered around the areas of power generation and electric machinery associated with the mining industry.

The basic engineering curriculum focused on fundamental instruction in the sciences which included physics, chemistry, and mathematics through differential equations. Electrical engineering courses covered DC and AC theory, current distribution, fundamentals of electric and magnetic circuits, motors, generators, transformers, transmission lines, and electric machinery design for mining, control of power stations, generating plants, and substations.

South Dakota School of Mines,

Edwin Espey Clark

Bachelor of Science in Electrical Engineering

EE Clark, who had graduated in 1918 with a degree listed as BS in Mining Engineering, asked to have this degree withdrawn and replaced with a BS in EE. This action was granted by the SD Mines on May 27, 1920, and confirmed by the SD BoR on June 1, 1920, and the EE program was "officially" born.

EE Clark would continue his association with SD Mines for over 40 years. The EE department has an active endowment for "Edwin E. Clark Professorship in Power and Energy in Electrical Engineering".

The Kammerman Years: 1920-1956

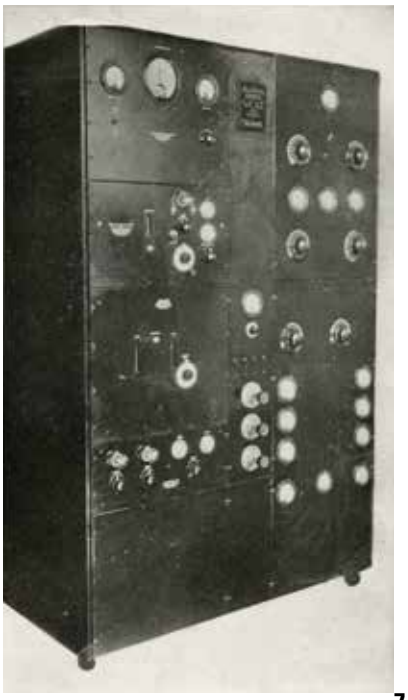
By 1921, with the official recognition by the SD BoR, the electrical engineering program was housed within its own Department of Electrical Engineering (having been split off from the Physics & Electrical Engineering Department) and consisted of a faculty of two members—Professor John Kammerman and E.E. Clark. During these years, electrical engineering classes were held in the new "Engineering Building," now known as the McLaury Bulding, which still stands today.

Professor Kammerman served as the Department Head from 1920 until 1956, with only two brief interruptions due to his military deployment in World War II and a brief period during which an age limit existed for department heads.

A new area of instruction had appeared in the department as a result of on-campus instruction of military personnel during World War I in radio technology. Courses in telegraph and communications were added to the curriculum. In addition, the faculty of the EE department obtained equipment from the Radio Corporation of America and assembled a 100 Watt transmitting radio station which debuted in July of 1922. Known as the "Wildcat Station," it continued to broadcast throughout the Black Hills area until 1952 and was entirely maintained, operated, programmed, and staffed by the EE department. However, increased teaching loads and antiquated equipment which could no longer meet FCC requirements forced the department to retire WCAT, the oldest broadcasting station in South Dakota.

A variety of curriculum changes occurred throughout this period with an initial emphasis on design and applied mechanics which resulted in the elimination of courses in the natural sciences and differential equations to make room for the new courses. Technical writing was introduced in 1932 and has stayed in the curriculum to this day as one of the defining components of a degree obtained from SD Mines. In 1935, the SD BoR authorized the granting of a Master of Science in Electrical Engineering degree. Electronics, industrial electronics, communication circuits, and radio circuits were added to the program course offerings during the period up until the end of WWII. In 1944, President Roosevelt signed into law the G.I. Bill which resulted in a large increase of students attending the school (which was now known as the SD Mines). As the student population rose, the EE faculty numbers also increased from two to five by 1950. National accreditation for the EE program occurred in 1936 and continues to this day by the Accreditation Board for Engineering and Technology (ABET, formerly known as Engineer's Council on Professional Development.)

The final years of the Kammerman era found an electrical engineering program rich in fundamentals with focus areas officially offered as either a "power option" or "electronics option." A total of 15 different senior-level EE courses were offered in the 1956 catalog and expanded graduate level courses were becoming available in addition to research credits necessary for a MS thesis. It was during this time that the first international student graduated from the EE program in 1954. This individual was Norwegian and began a close connection between the EE department and the Norwegian engineering community. Over the years, not only would many Norwegians graduate from SD Mines (making SD Mines the largest engineering educational facility for Norwegians outside of the country of Norway), but professor exchanges with Norwegian research and education institutions would occur.



The Hixon Years: 1957-1974

Dr. William A. Hixon had joined the department in 1952 and moved to the position of department head in 1957 following the retirement of Professor Kammerman. As technology advanced rapidly, the field of electrical engineering broadened and the faculty and department were faced with the question of how to best educate their students. The curriculum reflected their decision to maintain a solid set of required fundamentals including differential equations and solid-state physics. The power and electronic options were no longer set out in the curriculum but seniors were given a choice of 11 credit hours of electives to pursue specific electrical engineering focus areas. In 1962, Professor EE Clark retired from the department after 40 years of educating over 300 electrical engineering graduates. It was also during this period that the first female EE student graduated in 1957.

The rapid advance in technology was evident by the 1958 inclusion of semiconductor theory into the junior level electronics course. In June of 1961 it was announced that the school had accumulated sufficient funds over a five year period to authorize the purchase of the first data processing equipment necessary to begin instruction in the field of electronic data processing. This equipment consisted of an IBM 1620, proudly hailed as a completely transistorized digital computer, and was placed under the responsibility of the EE department. The computer was housed in the McClaury building (along with the EE department) and was used campus-wide under the tutelage of EE department personnel. By 1964 a one credit hour sophomore-level course in digital computer programming (EE 200) was required in the EE curriculum. Curriculum during this time also required three semesters of circuits, two semesters of electronics, fields, electric machines, and linear and feedback control systems and allowed for 10 hours of senior electives. As the use of computer capabilities became an accepted part of campus culture, the computer center evolved to a stand-alone facility in 1965 and was the precursor to our Information Technology Department of today.

Research and publications abounded during the Hixon years and the first student with an MS in EE graduated in 1958. Research areas aligned with the interests of the faculty with the result of the first nationally recognized publications in high-voltage research, nondestructive testing of nuclear fuels, solid-state materials, gaseous electronics, and a textbook titled *Circuits, Signals, and Networks* published by Macmillan Company. The department flourished and student numbers grew dramatically requiring three additional faculty to be hired. All ten faculty were involved with teaching and research to the extent that a PhD in electrical engineering with a concentration in electronic materials was proposed and approved by the SD BoR in 1967. Also as a result of faculty research activities, two new laboratories were added into the department—a solid-state materials lab and a gaseous electronics lab. A look into the 1968 catalog also verified the department's research efforts with a listing of 37 graduate level courses. The first PhD in electrical engineering graduated in 1971.

By 1971, it was apparent that a new building was required to house the rapidly growing EE department, computer center, and physics department. To accommodate these needs, the SD legislature authorized $1,819,000 for the Electrical Engineering and Physics (EEP) Building and construction began. This construction was primarily accomplished by contractors made up of SD Mines alumni-owned companies. Details of the layout, laboratories, and teaching areas were designed by the department and emphasized adaptability with the two central teaching labs equipped for all routine measurement and experimentation in circuits and electronics. The new EEP building opened in 1973 and also included a solid state laboratory with its associated heavy furnaces and the relocated computer center.

Curriculum changes included a transition to a "systems" point of view such that all courses were taught in context to each other and would provide the graduate with those fundamentals necessary for an adaptable engineer in the workplace. The final achievement of the Hixon era was the appointment of Dr. Michael Batchelder in 1974 to the department to bring critically needed expertise in computer systems engineering. Dr. Batchelder's service to the department has continued to the present and spans over 40 years.

The Feisel Years: 1975-1983

Following the untimely death of Dr. Hixon due to a heart attack, Dr. Lyle Feisel became the new EE department head. This period was a difficult time due to the success in enrollments for the school and department. Salaries in industry and large universities had lured away faculty and made vacancies difficult to fill. As a result, teaching loads increased and research and scholarly output from the department was reduced to the extent that the department's PhD program transitioned to a PhD in Materials Engineering Science with the last PhD in EE degree awarded in 1983.

Perhaps in part due to the increased teaching loads, faculty adjusted their research and innovation into the area of engineering education. One such effort which received national attention included the creation of a microprocessor kit called Tech Education MicroProcessor (TEMP), designed by the faculty in the department and produced locally. Students in all engineering curriculums would build and test their own microprocessors which were then used in a number of laboratory experiments.

It is interesting to note that this same practical approach to instruction remains as the method of instruction used today in EE 322 Electronics II where EE juniors build their own radio as a practical method of instruction in electronics. This course remains a popular and effective teaching method as evidenced during senior exit surveys. The EE department continued its engineering educational innovations with the Comprehesive Aid to Undergraduate Science and Engineering (CAUSE) program, funded by the NSF, to find a method of providing auto-remediation of prerequisite deficiencies for students. A set of slide/audio tape modules were created for all required EE courses, fundamental math, and FORTRAN courses and a separate lab was set aside in room EEP 307. The student could review subjects and self-test their mastery through this method.

It was also during the era of Dr. Feisel that EE 493 EE Design Project moved from a senior elective course to that of a required part of the curriculum. This course required each student to individually pursue a development project of their own which would simulate a future industrial design experience. To illustrate the importance of documentation, Dr. Feisel would wait until the work was well underway in the semester, say "Boom!", and declare everyone dead. He then would redistribute the students' project notebooks and ask for a status report on the project from the newly assigned engineer. Creativity in education was flourishing in the EE department.

The Riemenschneider Years: 1984-1994

Technology continued to advance as, under Dr. Riemenschneider's leadership, Texas Instruments assisted the EE department with the resources to equip both the department and campus with ready access to personal computers. The days of punchcards and a main-frame computer center were rapidly evaporating. Curriculum for all engineering students required two basic computer courses in numerical analysis (FORTRAN) and microprocessors. Electrical engineering majors continued their curriculum of fundamental instruction in circuits, electronics, electromagnetic fields, properties of materials, and signals and systems. Senior electives consisted of 15 credit hours of instruction in the area of their choice: power, digital systems and microprocessors, control systems, and electromagnetics.

By the end of the Riemenschneider era, the university had been connected via fiber-optics to all other SD campuses and utilized RISC based workstations throughout the campus. Instruction in computer engineering-based courses as a focus area had evolved to such a degree that in 1994 a BS in Computer Engineering (CENG) was being offered. The curriculum was developed by EE and and Computer Science (CSC) departmental personnel and was housed within the newly expanded Department of Electrical & Computer Engineering (ECE).

The Rotating Department Chairs: 1995-2010

Administrative reorganization of SD Mines into a set of colleges with rotating department chairs occurred during this time period. Drs. Batchelder, Simonson, Hasan, and Hemmelman would each take turns as the chair of the ECE department with one or two periods of service. As a result of both accreditation requirements and alumni input, "teaming" became an emphasis in engineering education. Senior design courses were now team projects that covered two semesters of effort. Teaming was further strengthed when the EE and ME departments collaborated together to initiate the Center of Excellence for Advanced Manufacturing and Production (CAMP) program to allow hands-on engineering education for inter-disciplinary teams of students.

In 2000, the first endowed faculty position at SD Mines was established with the creation of the Stephen P. Miller Endowed Chair in Electrical Engineering. This endowment and subsequent research by EE faculty helped lead the way to the establishment of a dedicated lab for telecommunications-related research, a partnership of research activities with the Army Research Lab at both the undergraduate and graduate level, and the expansion of research into the SD Technical Development Lab.

The end of this period in ECE history concluded with the unveiling of a new Renewable Energy Resource Facility donated by Black Hills Power. This facility was donated to provide a resource for researching wind and solar energy opportunities and has generated a number of EE senior design projects over the following years.

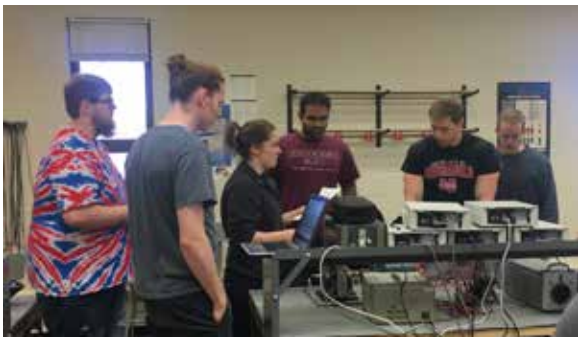
EE Department Today: 2011- present

The period from 2011 until today has seen the return of Department Heads with Dr. Kazem Sohraby (2011-2015). During Dr. Sohraby's tenure, curriculum for CENG and EE students remained unchanged with fundamental courses in EE and CENG which included circuits, electronics, signals and systems. EE majors added instruction in electronics, electromagnetics, energy systems, and properties of materials to their required curriculum while CENG majors included computer science fundamentals, data structures, software engineering, and operating systems. A total of 11 credit hours of electives were available for students in both disciplines to further develop their focus areas.

Research activities expanded slightly to include more undergraduates as a result of student initiative and mentoring by their advisors and faculty. Areas of interest included autonomous submarine, ground and aerial robotics, and crop imaging.

Following the departure of Dr. Sohraby, Mr. Scott Rausch served as the Acting Department Head during 2015 – 17, while a two year search for a new department head was carried out. During this period, a number of new adjunct faculty were added to the department in the form of retired alumni with industrial and business experience. These faculty continue to provide students with a glimpse into their future careers by their mentorship during senior design and internship/co-op opportunities. Also under Mr. Rausch's leadership, the ECE successfully received a six year reaccreditation for both the EE and CENG programs with no issues noted. In 2017, Dr. Magesh Rajan was appointed as Head of the ECE deparment. Once again, changes occurred rapidly in part due to the appointment of a new university president, Dr. Jim Rankin, and his vision for the future. Adminstrative emphasis is once again placed on prioritizing an active research and graduate program for every department. With the resignation of Dr. Rajan to pursue research related endeavors, Dr. Thomas P. Montoya was appointed Interim Department Head for the EE Department in the Fall of 2019.

Recent changes within the department include the renovation of the 43 year-old circuit labs in the EEP building. While these labs have seen hundreds of students pass through them and sit in the same chairs, they have served their purpose and were renovated during the summer of 2018.



New faculty have brought additional expertise in areas associated with plasma, autonomous vehicles, power electronics, and wearable sensors and numbers of graduate students have increased. The final large change is reminiscent of that of 100 years before when the growth and progress of the Physics and Electrical Engineering Department resulted in the creation of an independent Department of Electrical Engineering. In today's fast-paced world of technological advancements, once again we see the vision of SD Mines's leaders as they created a new department of Computer Science and Engineering to allow greater focus and growth for both the Electrical Engineering and Computer Engineering curriculums.

The future of the Department of Electrical Engineering promises to be exciting as we move forward in our exploration of new research projects for graduate and undergraduate students, the addition of a number of minors and certificate programs within the field, and a continued emphasis on a fundamentals-based education built on practical, hands-on learning.

EE Department Program Offerings and Curriculum Emphasis Areas

In the 100 years of electrical engineering instruction at SD Mines our program offerings have expanded from the initial Bachelor of Science program in Electrical Engineering to include several types of graduate programs and most recently three new minors.

The Electrical Engineering BS curriculum continues to be built upon a 4 year, eight semester curriculum. However, to ensure that the program remains relevant in today's fast paced world, the department has an Undergraduate Curriculum committee which meets throughout each term. As a result of this committee's work during 2019, a number of changes have recently been approved by the South Dakota Board of Regents for the curriculum. All students at SD Mines, during their first two years, take classes to fulfill the general education requirements set by the South Dakota Board of Regents in areas such as English/communication, social sciences, humanities, mathematics, and natural sciences. In addition, EE students will now take two freshmen level classes in electrical engineering—Explore Electrical and Electronics Engineering and Foundations of Electrical and Electronics Engineering. These courses will allow our students an opportunity seldom found in BS curriculums to begin their technical instruction a full year earlier than the norm. The courses have been developed to explore the depth/breadth of the electrical engineering profession through an emphasis in hands-on activities designed to teach the basics of digital and analog electrical components. Following the freshmen introductory courses, students continue to explore electrical circuits, electronics, and sensors in greater depth with supporting classes in computer science and mathematics. The junior year is largely devoted to core electrical engineering courses in electronics, electromagnetics, controls, signals, materials, and power engineering with a heavy emphasis on hands-on experiences. During their senior year, EE students are given the opportunity to focus on specific interests or specialties within electrical engineering with electrical engineering emphasis electives as well as technical electives. They also engage in a two-semester capstone design experience where the skills they have developed are applied. A second curriculum change which we have instituted is the inclusion of experiential learning electives which are meant to give students an opportunity to participate in service learning, entrepreneurship, innovation, or research opportunities. We believe the new curriculum will allow students greater freedom to tailor their education while still receiving the core knowledge required by our profession.

The graduate program available through the EE department allows students to receive an MS EE degree via a variety of options. While a total of 30 credits is required to obtain a masters degree, it can be achieved through one of three paths- a thesis option, a non-thesis (course-work only) option, and the newest MS program option- the Accelerated Masters. An MS EE generally takes two years to complete but the Accelerated Masters program, which is available to SD Mines students only, allows our students to complete both their BS and their MS degrees in a total of five years. Students in this program begin graduate level instruction during their traditional senior year by selecting specific electives which can be dual counted for both degrees.

The last large program initiative resulting from our curriculum review is the introduction of three new minors being offered by the EE department. Since electrical engineering and electronics are a key component found within many multi-disciplinary majors (such as mechanical engineering, power engineering, biomedical engineering, and computer engineering), we believe that a minor documenting additional expertise in such areas will serve many SD Mines students well in their future careers. To fulfill this need at SD Mines, the EE department has developed both a minor in Electronics Engineering and Technology and a minor in Electrical Engineering. Our final minor which should be available in fall of 2020 with be a Systems Engineering minor and will be open to all SD Mines students. It is being developed to take advantage of system based courses available in the Electrical Engineering curriculum (or other programs) while teaching the fundamental approaches used in system engineering itself. The complexities associated with design and development of new products, processes, and technology show the value associated with learning a 'systems' approach.

Undergraduate Education:

Experiential Learning is the Key

SD Mines has long been recognized as an institution that believes in providing its students with a combination of academic instruction blended with significant hands on learning experiences. The EE undergraduate education seeks to accomplish this by providing students with opportunities which should not only teach them the fundamentals of electrical engineering but help them expand those skills needed for the communication, interpersonal interactions, and community involvement necessary for an engineer in the modern world. This education occurs both on campus-in the classroom, laboratory, campus clubs and events—and off-campus through internships and co-op programs.

Quality Instruction & Applied Learning

The broad field of electrical engineering encompasses many areas of specialization. To provide students with both depth and breadth, we focus on three factors: **1)** mathematics and theory, **2)** laboratory and project experience, and **3)** aspects of professional engineering practice.

1) A strong foundation of mathematics and theory serves as the groundwork for exploring the diverse kinds of engineering problems our graduates will face. Tomorrow's engineering solutions to today's problems will involve integrating approaches from a combination of disciplines, applying physics (increasingly at the quantum level), and using advanced mathematical and computational techniques. In addition to the state's and university's core math and science requirements, the EE department requires all graduates to take courses in probability & statistics, and electromagnetic & optical properties of materials. We also weave computational mathematics and physics into the fabric of every EE course.

2)Extensive laboratory and project experience illustrate mathematical and theoretical concepts. Just as importantly, it builds practical skills and confidence so our graduates can jump into design, fabrication, and testing. The companies who return year-after-year to recruit love that our graduates are able to hit the ground running. Starting with our freshman level and continuing through senior electives and design, nearly every course we teach includes laboratory and/or project-based learning experiences.

3) Intentional exposure to professional engineering practices will give our graduates some of the skills they will need to lead successful careers. Engineers often are called upon to shift their focus from technical aspects toward a variety of other activities: project management, team leadership, technical communication, marketing, finance, legal considerations, entrepreneurship, etc. We begin bringing these issues into our students' awareness at the very beginning of their coursework as freshmen and focus on them acutely in their two-semester senior design courses.

To jump-start our incoming freshmen in these areas, we are rolling out two new courses: EE 110 "Explore Electrical & Electronics Engineering," and EE 120 "Foundations of Electrical and Electronics Engineering." These courses introduce the basic analog and digital circuit techniques they will use throughout their EE education and careers. Students in both courses will spend significant time conducting laboratory explorations and completing projects. We will give students examples of the kinds of work that electrical engineers do in the real world so they can begin to envision their own futures. We also feel that the freshman level is not too early to start exposing them to professional practice topics such as ethics & responsibility, teamwork and communication, and economy of design.

We all know that our careers rarely proceed in the orderly progression we might have envisioned as students. We feel this three-pronged approach will give our graduates the flexibility and resilience to adapt and succeed at whatever they encounter during their professional futures.

Dr. Shannon Thornburg, an SD Mines alumnus (BS ME 1988, MS EE 1989), did his graduate studies in aerospace engineering at Stanford University (MS. AA 1990, PhDAA 1995). He spent the next 20 years running Dakota Craft, Inc., a family business in Rapid City. After selling that company in 2015, he began teaching in the EE department and is now a full-time lecturer. In addition to teaching freshman- and senior-level courses, he serves as the EE department's Corporate Engagement Liaison, focusing on strengthening corporate partnerships for scholarships, lab/equipment/project sponsorship, and employment for our students.

Educator with focus on Fundamentals and Service

Fundamentals

At SD Mines, Dr. Thomas Montoya has taught nineteen different undergraduate courses, the most often being EE 220 (Circuits I) at 25 times, as well as eight different graduate courses. In EE 220, he focuses on fundamentals and hands-on learning for the undergraduate EE students. He regards this course as the gateway into the EE curriculum, setting the foundation for all subsequent EE courses. As such, he strives to instill good work habits and a sense of professionalism in undergraduate EE students. Dr. Montoya's second most often taught course (17 times) is EE 381 Electric and Magnetic Fields. EE 381 is a core course in electrical engineering. It is also a favorite of Dr. Montoya's as it is the introductory course for his specialty area of applied electromagnetics.

Campus Service & Faculty Leadership

The faculty of the electrical engineering (EE) department demonstrate their leadership and service to the SD Mines. Some examples of these faculty leadership and service opportunities include the Faculty Senate (FS), the University Curriculum Committee (UCC), and the Council on Graduate Education (CGE). The Faculty Senate represents the SD Mines faculty in providing advice to the President on all matters relating to the responsibilities of faculty including the formation of university policy, the maintenance and development of curriculum, and the establishment of academic standards where such matters

of interest to the faculty are specifically addressed within the Agreement between the Board of Regents and the Council of Higher Education. Prior to stepping into the position of Interim EE Department Head, Dr. Montoya served as the Chair of the Faculty Senate. In this role, he held general faculty meetings and had a place on the University Executive Committee and the University Cabinet. The University Curriculum Committee reviews, corrects, and endorses curricular developments that in turn are sent for action by the Faculty Senate. Dr. Montoya has also represented the EE department at the University Curriculum Committee and chaired the University Curriculum Committee for several years. In addition, Dr. Montoya has served as the Undergraduate Program Coordinator for the EE department and has been the faculty advisor for IEEE-Eta Kappa Nu for many years. Professionally, he has been active with IEEE and the IEEE Antennas and Propagation Society as well as the South Dakota Academy of Science where he has represented SD Mines on the Executive Committee for many years.

Dr. Thomas P. Montoya began his association with SD Mines in 1982 as a freshman and went on to graduate with BS degrees in Electrical Engineering and Physics in 1987. Following graduation, he was an Electrical Design Engineer with Texas Instruments in Colorado Springs, Colorado and McKinney, Texas and also attended graduate school at the University of Colorado at Colorado Springs. After graduating from UCCS with an MS EE degree, he studied at the Georgia Institute of Technology as a Presidential Fellow and later National Defense Science and Engineering Fellow. He earned a PhD in Electrical Engineering in 1998, whereupon he joined the faculty of the University of Tennessee - Knoxville (Go Vols) before returning to SD Mines in 2001. His research is the in the area of applied electromagnetics and research interests include antennas, direct-write fabrication of devices on rigid and flexible substrates, ground penetrating radar (GPR), numerical methods, and material properties at microwave frequencies.

Tom met his wife Amy when they were students at Mines, and they will celebrate 32 years of marriage this year. They have two children: Andrew, a newly-minted EE alumni, and Natalie, who attended Mines as a dual-enrolled high school student and is now an undergraduate at the Massachusetts Institute of Technology. Having survived the dad-coaching years of pee-wee soccer, Little League, midget football, etc., he is currently renewing his interests in woodworking and home brewing.

Hands on Learning Electrical and Electronic Circuits

In the electrical engineering program at the SD Mines, we believe in a fun individualized hands-on learning experience. Fun because it is very rewarding to be able to put electrical engineering theory, science, math, and simulation into real-world problem solving and design. Not only do we teach the theory in the classroom, but we also practice real-life design and circuit debugging in the laboratory.

This hands-on learning allows our graduates to perform and contribute the first day on the job not just after months or years in their careers. In the labs, we solve real issues using root cause analysis on analog circuits that were built by students and their classmates, rather than canned lab experiments. Graduates find this approach rewarding and a practical way of tying theory and simulations to real hardware and real problems. Students are able to conceptualize the theory into understandable individual thoughts. This individualized learning and thought process is very important because we all do not think or learn the same way.

In the lab, we learn how to use oscilloscopes, meters, and vector network analyzers to understand the circuits and the physics of devices, along with details of models used for transistors and integrated circuits. This work allows us to use these techniques on both narrowband and wideband circuits. Students continue to work extensively to bring models used in simulators such as PSpice and ADS (EM, circuit and system simulator) to agree with what was measured. With these hands-on skills, students are able to design and analyze such things as both active and passive filters, 3-phase power systems, RLC circuits, and a host of other engineering designs.

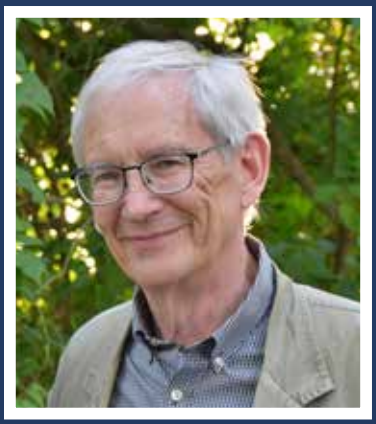
SD Mines's EE program does not believe that dry lectures are best practice. We believe in collaboration between professors and peer students providing critique, comparisons, and contrasts between work, theory, and simulations with real-world results. This allows us all to reflect, apply learnings to real life issues, and learn from novice mistakes in the lab and not on the job. It has been said and we will repeat: "I hear and I forget. I see and I remember. I do and I understand."

Adjunct Faculty have always been a valuable asset to the EE department and have helped enrich students through their teaching and mentorship. Over the years, open teaching positions have often been filled by alumni/engineers who live in the Black Hills. Our students value the experience these faculty bring to their education and have often gone the 'extra mile' to nominate adjuncts for recognition awards for excellence.

Most recently, Sam Babb (upon the request of an EE alumnus) agreed to relocate during the 2018/2019 year to assist the department as an Adjunct Professor/Instructor in Circuits and Electronics during a search for new faculty. Mr. Babb came to the department with a 38 year history as a design engineer, consultant, and manager at Hewlett Packard Enterprise. During his time with HP he was part of a program which lent selected engineers to universities. As with all our department adjuncts, Mr. Babb was a tireless instructor and mentor spending countless hours helping students both inside and outside of the classroom. Mr. Babb's impact on students resulted in his nomination and subsequent award of the Bernard A. Ennenga Award in May 2019. While Mr. Babb has returned to his home in Colorado, many of our alumni live/work/and retire to the Black Hills and return to the department to lend their skills to help educate the engineers of the future.

Dan Mulally holds BS and MS degrees in Electrical Engineering from South Dakota School of Mines & Technology. He does independent contracting and is president of Mulally Consulting while also serving as the program administrator for the West Dakota Water Development District. Some of his previous work has included developing an in-situ atmospheric sensor (TAMDAR) for commercial aircraft. The sensor measurements included: temperature, humidity, winds and atmospheric turbulence. His work involved both algorithm and hardware development and intensive statistical data analysis. He has presented papers at annual American Meteorological Society meetings on its performance and improvement to weather forecasting. Mr. Mulally has worked closely with NOAA and NASA on quantifying sensor accuracy. Other work also included RF design for FM and television equipment, modulation and demodulation techniques for a digital television system, and he worked on the design of a digital single-phase to three-phase converter. Over the years, Mr. Mulally has brought his broad industrial experience to the department by teaching various electrical engineering classes at SD MINES including electronics, digital signal processing, and most recently our fundamental energy systems class.

Scott Rausch graduated with a BS in Electrical Engineering from SD Mines and spent over 32 years in private industry primarily associated within the avionics field. Mr. Rausch served in both engineering project design and management culminating in a position as Vice President of Engineering. Following his retirement, he returned to Rapid City and began his work within the department in 2007. Since that time, he has been a tireless supporter for the department and has taught numerous courses, donated electronic test equipment, served as interim Department Head, and influenced many students to choose SD Mines and the department during his prospective student tours. Mr. Rausch continues to return to the department when needed and is currently teaching Electronics I during Fall 2019.



Dr. Michael Batchelder, Professor Emeritus, has been a foundational member of the EE department since 1974. "Dr. B" is primarily responsible for bringing the department into the computer era and has advised and mentored students throughout his tenure with the university. He continues to return and assist the department whenever we call on him and has most recently helped with the EE 322L Electronics II Lab in the spring of 2020. As our alumni know, this course is a foundational course in electronics with its second semester devoted to hands-on learning through building a radio. A knowledgeable lab instructor/coach is invaluable to students for this class.

Over the years a number of other individuals have returned when called to fill departmental needs. One such individual is Dr. Larry Simonson, a graduate of SDSMT (BS, MS, and PhD) who has devoted the majority of his career to the EE department and the university. Following his retirement as an active faculty member and while busy with Alumni, Foundation, and university needs, Dr. Simonson has stepped in whenever necessary over the years to teach foundational courses.

Hands on Learning through Senior Design

Senior Design, also known as the "capstone project," is the ultimate in hands-on learning, because it uses the real world as a lab. Senior Design introduces students to the realities of engineering by taking them through an actual engineering design cycle: envisioning a product mission statement; identifying customer needs; defining requirements and specifications; brainstorming and qualifying design alternatives; managing project progress; conducting design reviews; building a prototype; testing and qualification; and documenting their finished product and design process. Additionally, students are introduced to the patent process; safety and regulatory considerations; global, ethical, and societal issues; and manufacturability and reliability. If that sounds like a busy two semesters, you are getting the picture.

The natural way to learn about design is to do it. The process starts with the students choosing from proposed projects or proposing their own. Most proposed projects are defined and sponsored by industry partners, who also supply technical advisors and financial support, e.g., for buying the necessary components. Frequently, companies who sponsor projects do so at the impetus of SD Mines alumni who valued their project design experience.

Since most projects are multi-disciplinary, they are then staffed with interested students from electrical engineering, computer engineering, mechanical engineering, computer science, and other disciplines as needed to build suitable teams.

Students manage their teams with support from faculty and industry advisors who are there to make sure they don't get stuck for long. Lecture periods make up about an hour per week during two successive semesters, and students schedule their own team meetings and do the design work outside of the classroom. Senior Design typically results in a working device or product and the appropriate documentation. If the final product isn't proprietary to the sponsor, it will be publicly displayed at the design fair at the end of the second semester. Many of the projects also represent SD Mines in national competitions, such as the Moonrockers team, which competes in NASA's Robotic Mining Competition every May. Also, it is not uncommon for Senior Design projects to spawn a patent.

As the instructor for Senior Design, Mr. Kolb's industrial experiences mold students into productive engineers.

Mr. Lowell Kolb has been instructing and helping out in various capacities since retiring from Hewlett-Packard Corporation in August 2014. Both his BS EE ('74) and MS EE ('75) degrees are from SD Mines. During his time with HP, he worked in varying capacities as an engineer in both manufacturing and research and development. During his last four years with HP he served as a Senior Regulatory Engineer with responsibility for electromagnetic measurement and compliance for HP products. To aid in the standardization and quality control of emissions he proposed and implemented the HP Site Reproducibility Program which is used in emissions test laboratories world-wide. He also was the project lead and manager for the design and construction of the HP 10m semi-anechoic chamber which upon completion had the best normalized site attenuation characteristics of any commercial 10 m chamber in the world. He currently holds 8 patents in EMI related designs.

Senior Design Projects

Below are a sample of just a few of the senior design projects undertaken by EE students over the last few years. As mentioned above, projects are sponsored by governmental, corporate, individual business, alumni, or faculty/student sponsors . Also, multiple sources/individuals. Oftentimes, a collaboration of multiple sources/individual work together to sponsor projects which have potential impact to everyone involved.

Governmental Associated Projects

NASA Robotic Mining Competition

The Moonrockers project began in the 2009-2010 academic year in response to NASA's creation of a collegiate Robotic Mining Competition. Fifty universities compete by designing and building a remote controlled or autonomous excavator that can collect and deposit Martian regolith simulant and/or icy regolith (gravel) within 10 minutes. Over the years, the senior design students have adjusted and (at times) redesigned their robot to add autonomy, implemented an articulated chassis, and improved the excavating and delivery systems of the icy regolith. In 2018, the team (Moonrockers) placed 4th in mining and 7th overall in a field of 44. The project is funded through both private donations, the Student Association, and the NASA South Dakota Space Grant Consortium. Student innovation and South Dakota resourcefulness has been noted by NASA when in 2016 the SD Mines robot won 2nd place in autonomy using materials costing $150 in contrast to the first place robot's $10,000+ system. A number of SD Mines alumni who were active Moonrockers are employed by NASA and other aerospace companies.

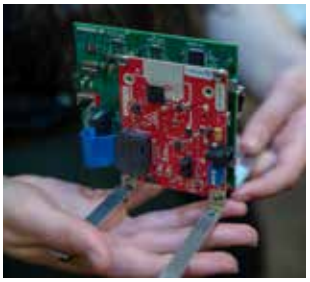
Acoustic Thermometer

Through collaboration with Raven Aerostar International, an industry need has been identified to measure the lift gas temperature within high-altitude balloons along with the temperature of the ambient air outside the balloon in real time at altitudes from 60,000 – 80,000 feet. Accurate temperature measurements of this nature would assist in validating the performance characteristics of future balloons. The project is sponsored by a NASA Undergraduate Student Instrument Project (USIP) grant, which pays for materials and equipment, plus stipends and travel expenses for the students to participate in an actual balloon launch. Three faculty members and one student are named as inventors in a patent application filed by SD Mines as a result of this project.

JPL Europa Ice Pick

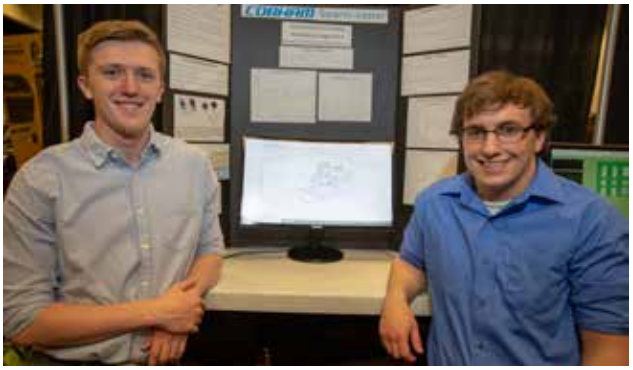
The NASA Jet Propulsion Labs (JPL) proposed a project to investigate and suggest means to remotely drill through ice 10 km thick on the surface of Europa (one of Jupiter's moons) to deliver a probe which will explore the liquid ocean underneath. The team works with an engineer at JPL who advises them in ways to approach the other-worldly problems associated with the project. Challenges include maintaining communication with the lander on the surface, dealing with the material which has been excavated, avoiding voids and subsurface debris such as meteorites trapped in the ice, all in a very cold (-170° C) environment with essentially no atmosphere. The nature of this project and difficulty in testing designs led to a uniquely theoretical research project for students on the team. Extensive modeling and simulation was used throughout the project with this resulting "cryobot" digging probe.

Synthetic-aperture Radar



Sponsored by Los Alamos National Lab and advised by a SD Mines alumnus, this project uses millimeter-wave technology presently in use in the automobile industry to maintain safe distances between vehicles even in dense fog. The objective of this project was to develop a system which can generate 3-dimensional images of fast events, e.g., something blowing up, and send the digital data in real time to a protected location where the data can be used to construct 3-dimesional pictures of the event. As reported in the team's final design documentation, "the project specifications were given as metrics under which to test the of feasibility of the radar as a form of high-speed object tracking. As such, our accomplishments not only include successful data capture and post-processing, but also demonstrations of the unfeasible nature of the radar platform for certain desired operating characteristics."

Industrial/Company Sponsored Projects



Swarmcopters

Cobham sponsored, funded, and provided technical support for a project to develop and implement an algorithm for an ensemble of autonomous quadcopters that move randomly in a defined space to avoid each other and obstacles in the space. The miniature robot copters communicate position, velocity, and intended path/destination so each robot can use the algorithm to choose the best action to avoid the other robots.

MOCHA Wide Spectrum Crop Monitoring System

This project goal is the development of a multi-spectral imaging device for crop observation. The device is intended for use on a tethered aerostat platform provided by industrial partner Raven Industries/Aerostar Inc. The recent release of a cost effective long wave infrared camera has made the construction of a cheaper multi-spectral imager for less than a thousand dollars possible. The imager that was built collects data in the ultraviolet, infrared, long wave infrared (or thermal), and visual spectral ranges or bands. The project was sponsored and funded by NASA USIP grant and includes testing on a Raven-Aerostar tethered aerostat (balloon).

Robotic Shed Delivery System

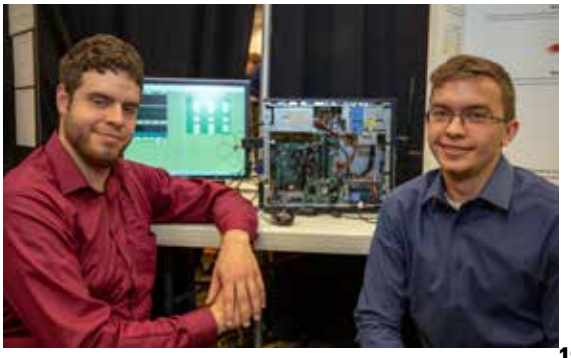
At the request of a company in Nebraska, Wright's Shed, a project to design and build a transport system consisting of four robots for delivering custom-built garden sheds was initiated. The robots will be positioned to support the four corners of the shed and operate together under user control to deliver the shed to its intended location, e.g., in the backyard of the buyer's property. Challenges include designing the tractor robots with sufficiently powerful electric motors to carry the payload, designing a battery power pack with the capacity to complete the task, and coordinating the actions of the four robots to make them work together in forward, reverse, and turning movements.

Rehabilitation Device

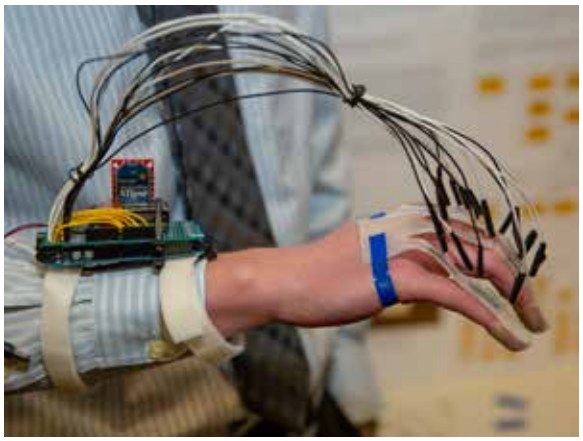
A local doctor of chiropractic sponsored a project to design and build a prototype therapeutic device to strengthen and retrain neck muscles for patients suffering from neck pain. The device is worn on the patient's head and exercises the wearer's neck muscles with circular forces to the head which can be varied in direction and intensity. Students on the team will be named in the patent application. The sponsor is considering filing at least one patent application from this project and will be moving the product into test trials in the near future.

Software Defined Radio PCIe Interface

L3 Technologies sponsored a project to develop a new high-speed communication interface between a Software Defined Radio (SDR) device and a host computer. Two ECE students were able to analyze existing hardware and software, identify bottlenecks that were slowing the transfer of data, and write new drivers that resulted an increase in communications speed of two orders of magnitude.



SD Mines Faculty/Student Projects



Flexible and Wearable Strain Sensor

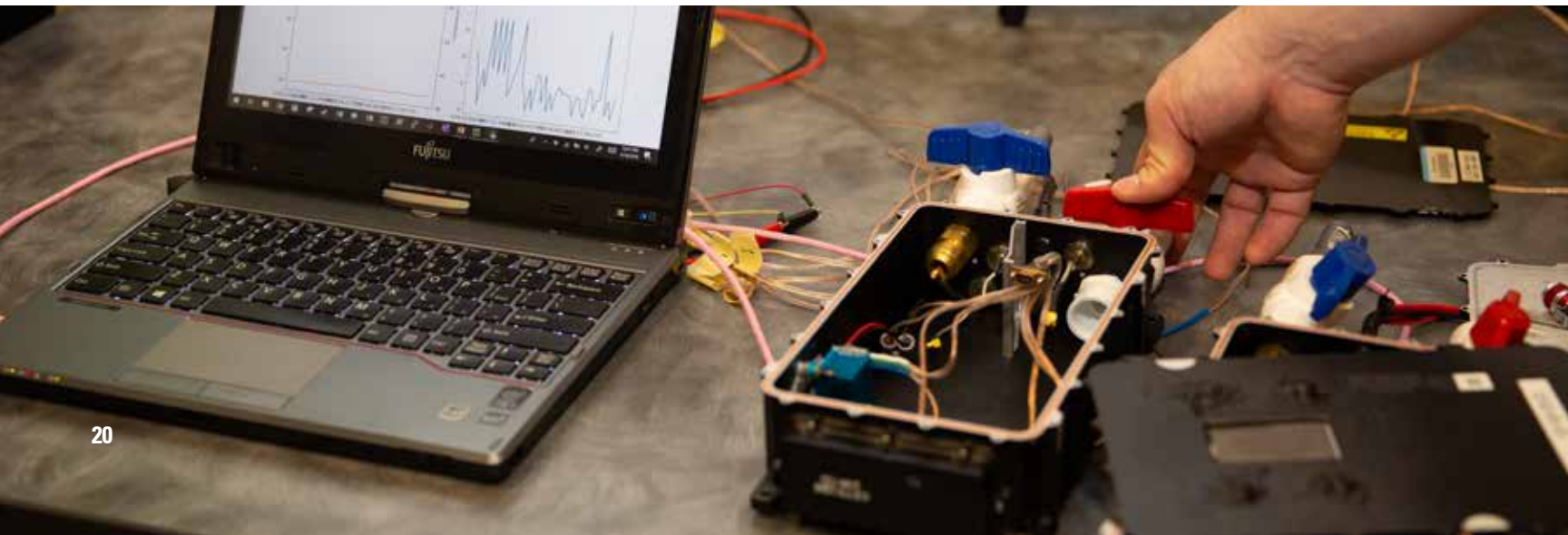
As part of an SD Mines professor's research into nanomaterials and flexible electronics, a senior design project to design and build a demonstration prototype that integrates flexible and wearable strain/pressures sensors on a wooden hand to trace the motion of fingers and interaction of the fingers with other objects was initiated. These flexible/wearable sensors are based on the materials developed on campus in a project funded by a NASA grant. This multidisciplinary project involved working closely with the material scientist/chemist who designed the carbon nanotube sensors. After investigation into the overall goal of the sponsor to develop a working prototype, this senior design project focused students efforts to expand the range of the new technology by using 3D printers for the fabrication of the sensors.

Communication Tablet using Eye Tracking

This project is the result of the initiative of two students within the department. Having worked with people with disabilities, the student originators saw a need for such a cost effective assistive device. These students found local sponsors to fund their project to design and build a prototype communication device using eye tracking. The device must integrate optical eye tracking and voice synthesis systems, along with audio speakers, into a single package which will readily mount, e.g., on wheelchairs. The target users for the device require a single package containing all hardware, software, and accessories sold as one product in order to comply with Medicaid regulations regarding subsidized purchases of assistive devices. Systems which currently serve the intended purpose consist of multiple components which must be purchased separately and assembled together. Since Medicaid is restricted to only paying for the least expensive component in the system, the disabled user is left to purchase the rest, which comes to around $5000. In contrast, the target sales price for this unit is $1000 - $1500.

IoT Sensor projects

Two different projects were sponsored, one by a student entrepreneur, the other by a local electronics manufacturing company, to develop Internet of Things (IoT) monitoring systems with various temperature, pressure, humidity, flow rate, and light and motion sensors for a variety of applications. Design challenges include hardening the sensors for their intended environments, providing sufficient battery life, and ensuring proper communication between the sensors and their base units and between the base units and the user's interface computer.

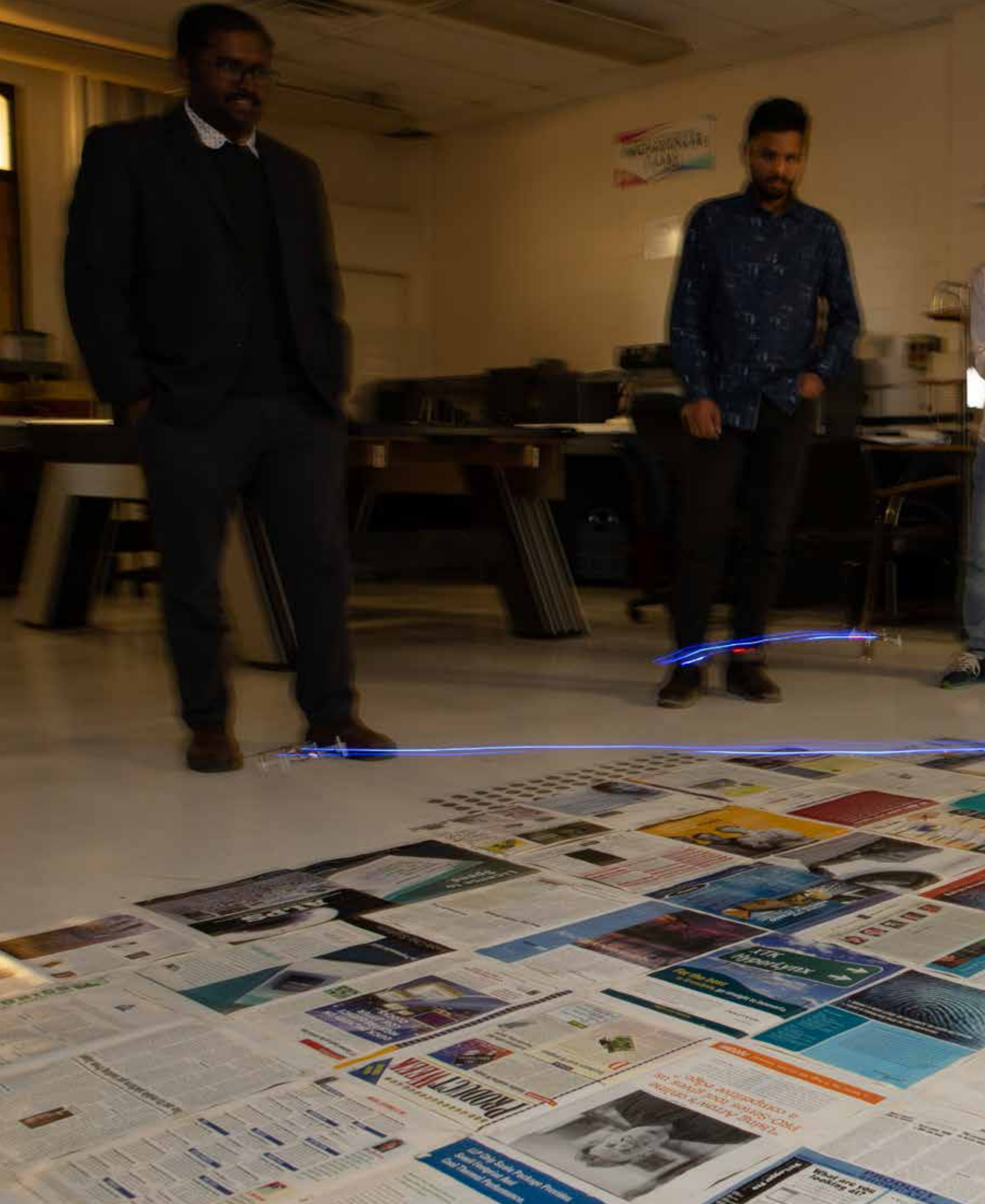


Faculty and Peer Mentorship and Advising for Students

The Electrical Engineering department places a strong emphasis on student advising. We acknowledge that the transition from high school to college can be difficult for students. To overcome this struggle and to support the academic journey of our students, the EE department provides two-tier academic advising. Upon acceptance into the Department of Electrical Engineering students are assigned an EE faculty advisor for an individualized and consistent advising experience throughout their academic progress. The students are encouraged to meet their academic advisors as and when they need assistance in their academics. Every semester each student is asked to meet with their academic advisor(s) at least once during Advising Week. Academic advising helps our students to make the right decision regarding course selections that in turn help them to complete their degree on time. In addition, academic advisors also help our students to choose an appropriate career path after graduation based on their preferences and interests. In the EE department, the faculty advisors are dedicated to assisting our students through the course of their academic journey.

In the second tier of advising, the EE department has dedicated Peer Mentors to help freshman students during their transition from high school to college. Incoming freshman students can feel overwhelmed with the new college environment and these peer mentors are there to help them feel comfortable. Peer mentors are upper-class students who are matched with incoming freshman students. Since peer mentors are almost of the same age group as the incoming freshmen students, they can easily relate to freshman and use their own experience to help make the incoming freshmen student's transition process comfortable. Peer mentors are selected by the department based on their academic excellence and interpersonal skills. Peer mentors shadow incoming freshmen during the initial weeks and make sure that they are available to provide assistance to the freshmen whenever needed. In addition, these peer mentors are trained to not only help freshmen in their academic transition but also assist them in getting acquainted with the department and university culture. Peer mentors remain in contact throughout the freshman year. Overall, mentors help their first-year mentees get acclimated to campus life, make the home-to-college transition easier, prepare for finals, and get connected to academic resources.

Ms. Neha Choudhary is a graduate of the Indian Institute of Information Technology with a MTech in Wireless Communication and Computing, the International Institute of Management and Technology with a BTech in Electronics and Communication Engineering , and is completing her dissertation work on her PhD in Engineering Education from Purdue University. She teaches EE 221 as well as EE 301/303 Basic Electrical Circuits for non-EE majors. In addition, she serves as a resource for the department in the area of student advising with her strong interest in innovative and creative teaching of engineering and information technology.



Graduate Education: Growth & Prospects

The Master of Science in Electrical Engineering degree was first awarded at the SD Mines and Technology in 1958 to a total of four graduate students. At that time, all graduate students pursued a course of study which included a research topic and a resulting thesis. Over the ensuing years, the MS program has expanded to allow students to obtain their degree via three options: (i) MS with thesis, (ii) an accelerated MS (for SD Mines undergraduates only), or (iii) a MS non-thesis (a course work only) degree. A total of 410 MS EE and 7 PhD EE degrees have been awarded by the department with 31 students completing their graduate education since the fall of 2013. Recently, the program completed its first documented graduate level program review in Fall 2018 culminating with an independent assessment that stated "…. the graduate program as SD Mines appears to be producing quality Masters' students who are readily employed by quality institutions across the country and internationally." With the influx of new research oriented faculty and their associated research laboratories, the department has experienced a growth in graduate student enrollment of 200% in the last two years.

Research – Autonomous unmanned & swarm systems for a better and safer future

Dr. Shankarachary Ragi | Unmanned & Swarm Systems (USS) Lab

Autonomous unmanned aerial/ground systems are transforming several industries including defense, agriculture, mining, transportation, oil & gas, and the consumer industry. At SD Mines, Dr. Shankarachary Ragi, an Assistant Professor in Electrical Engineering, is leading a research group to develop autonomous or semi-autonomous systems (with human in the loop) to meet the needs in the above-mentioned industries. There is a growing demand for autonomous operations with unmanned systems for various reasons including minimizing human health risks, maximizing revenue and profits, and maximizing productivity. Dr. Ragi's research group tackles several challenges such as inducing cooperative behavior among disparate unmanned agents (also called swarms), autonomous decision making in real-time, optimizing sensor resources, mapping environment, and tackling uncertainty.

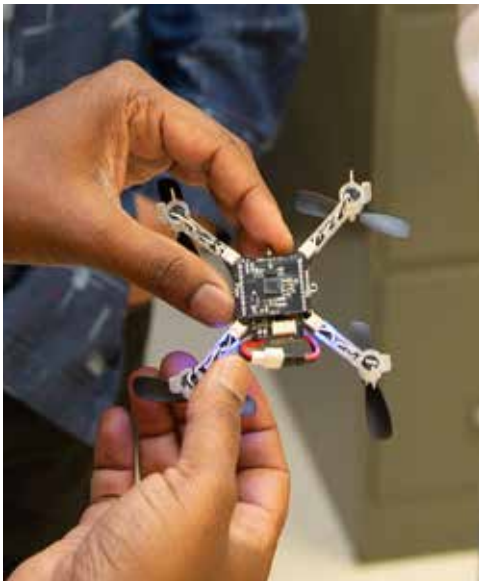
Defense. Autonomous unmanned systems and swarm-based systems can potentially transform defense operations such as target tracking, intelligence gathering, terrain mapping of enemy territories while minimizing the loss of life in the battlefield. Dr. Ragi's research is currently being funded by the U.S. Air Force to solve a complex optimization problem that often arises in autonomy operations of sensing systems possibly mounted on drones.

Precision Agriculture. With world population predicted to cross 8 Billion in 2022, there is a critical need to significantly improve agricultural practices to feed the growing population. Precision Agriculture is a practice of farming that uses the latest science and technology to maximize farm productivity in all seasons. Specifically, drone technology is gaining importance in precision agriculture with drone or a drone swarm and associated autonomy algorithms being developed to perform activities such as precision fertilizer spraying, weed detection and removal, precise crop health monitoring, etc. Dr. Ragi's group is currently exploring with local industries ways to develop drone and swarm-based solutions for precision agriculture.

Transportation. Fully autonomous cars may soon take over highways with self-driving capabilities needing little or no human support. With great advancements in sensing technologies (e.g., LiDAR, RADAR, optical), an autonomous car is now capable of sensing its environment more accurately and in more detail than a human driver. Dr. Ragi's group is developing methods to optimize sensor parameters on autonomous cars for effective tracking of moving objects such as pedestrians and other vehicles.

Infrastructure Inspection. Infrastructure inspection activities in industries such as oil & gas and cellular often involve human crews risking their safety to monitor the health of the equipment or perform inventory checks. For instance, to inspect anomalies in antennas or electrical units on cellular towers (e.g., rusting), a human crew scales these towers which are often 100-200 feet tall, significantly increasing their safety risk. Cellular companies are now investing resources to develop drone-based solutions to perform inspection activities autonomously without a human controller. Dr. Ragi is currently discussing with a cellular company the development of an autonomous drone-based solution to perform inspection activities such as rust detection, wiring anomaly detection, and inventory check.

Fundamental Research and Collaborations. In addition to applied research, Dr. Ragi is also doing fundamental research to develop theory (e.g., mathematical models, analyses) and algorithms in swarm autonomy and decision optimization. Some of the challenges in these fields require multidisciplinary efforts. To this end, Dr. Ragi is currently collaborating with researchers from disciplines such as mining engineering, computer science, applied mathematics, mechanical engineering, and operations research.



Media releases

Dr. Ragi's research has drawn attention from national and local media. In an interview with a local television station KEVN-LD, Ragi spoke at length about the impact of autonomous drones and swarm systems on various industry sectors including agriculture, transportation, and telecommunications. In a phone interview with local media, Ragi explained how his research can have a significant impact on agricultural technology and practices which is of particular importance given that agriculture is a key source of revenue for the state of South Dakota. This interview was published in the local newspaper, the Rapid City Journal. In addition, national media houses such as The Washington Times reported how Ragi's research can impact the cellular industry, especially how using drones for infrastructure inspection (e.g., cellular tower inspection) can alleviate human safety risks.

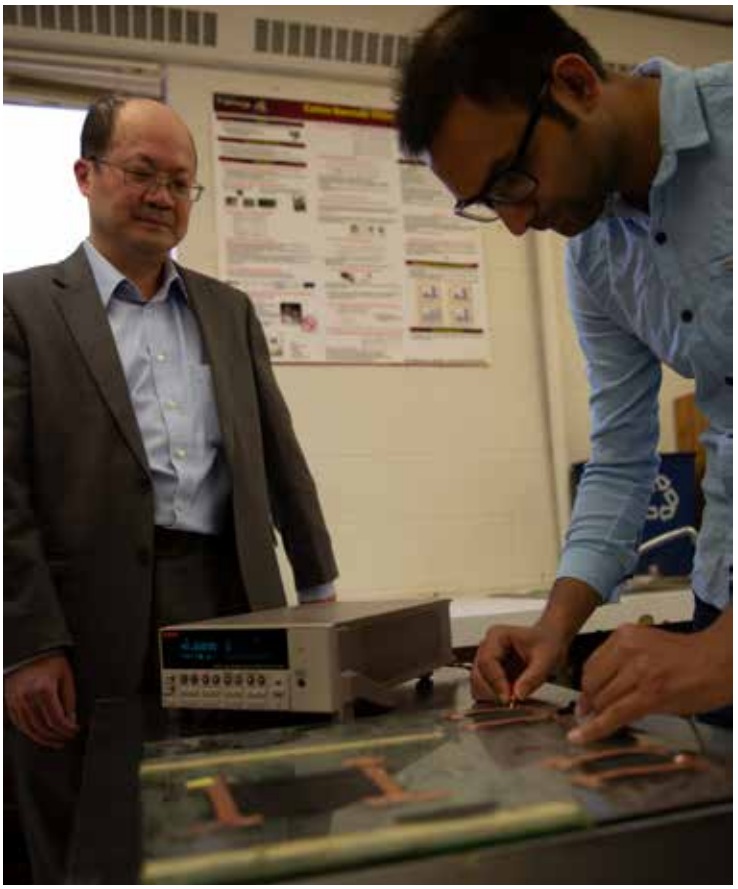
Funded research

Dr. Ragi's research is currently being funded by the Air Force Office of Scientific Research (AFOSR) through a subaward from Arizona State University. In this effort, Dr. Ragi is developing novel approaches to solve a class of optimization problems, where there are two or more competing or conflicting objectives. These problems typically appear while optimizing decision variables for autonomous unmanned systems. Several graduate students, advised by Dr. Ragi, are being supported under this AFOSR grant.

Dr. Ragi received his bachelor's and master's degrees in Electrical Engineering from the Indian Institute of Technology Madras in 2009, and the PhD degree in Electrical and Computer Engineering from Colorado State University in 2014. Before joining SD Mines, he held a postdoctoral position at Arizona State University in the Mathematics department. His current research is primarily in the areas of UAV swarm autonomy, cooperative control, motion planning, and decision making under uncertainty. Dr. Ragi has published over 16 peer-reviewed papers in various IEEE transaction journals and conferences such as American Control Conference (ACC) and International Conference on Acoustics, Speech, and Signal Processing (ICASSP), and published a book chapter. At SD Mines, Dr. Ragi leads the Unmanned & Swarm Systems Lab (USS Lab), where his team performs research activities including algorithm development, drone flight testing, sensor systems testing, and algorithm validation. Dr. Ragi currently serves on the editorial board for IEEE Access journal.

Research - Optoelectronics as a key to better life for our citizens

Dr. Haiping Hong | Optoelectronics Laboratory



Molecular nanomaterials, including nanotubes (CNT), carbon nanofibers (CNF), nano metal oxide, and nano metal particles, have the potential to demonstrate novel properties such as increased electrical, thermal, mechanical, and magnetic properties. As a result, research in this field will lead to advanced applications and implementation through the use of molecular nanomaterials for domestic and defense applications.

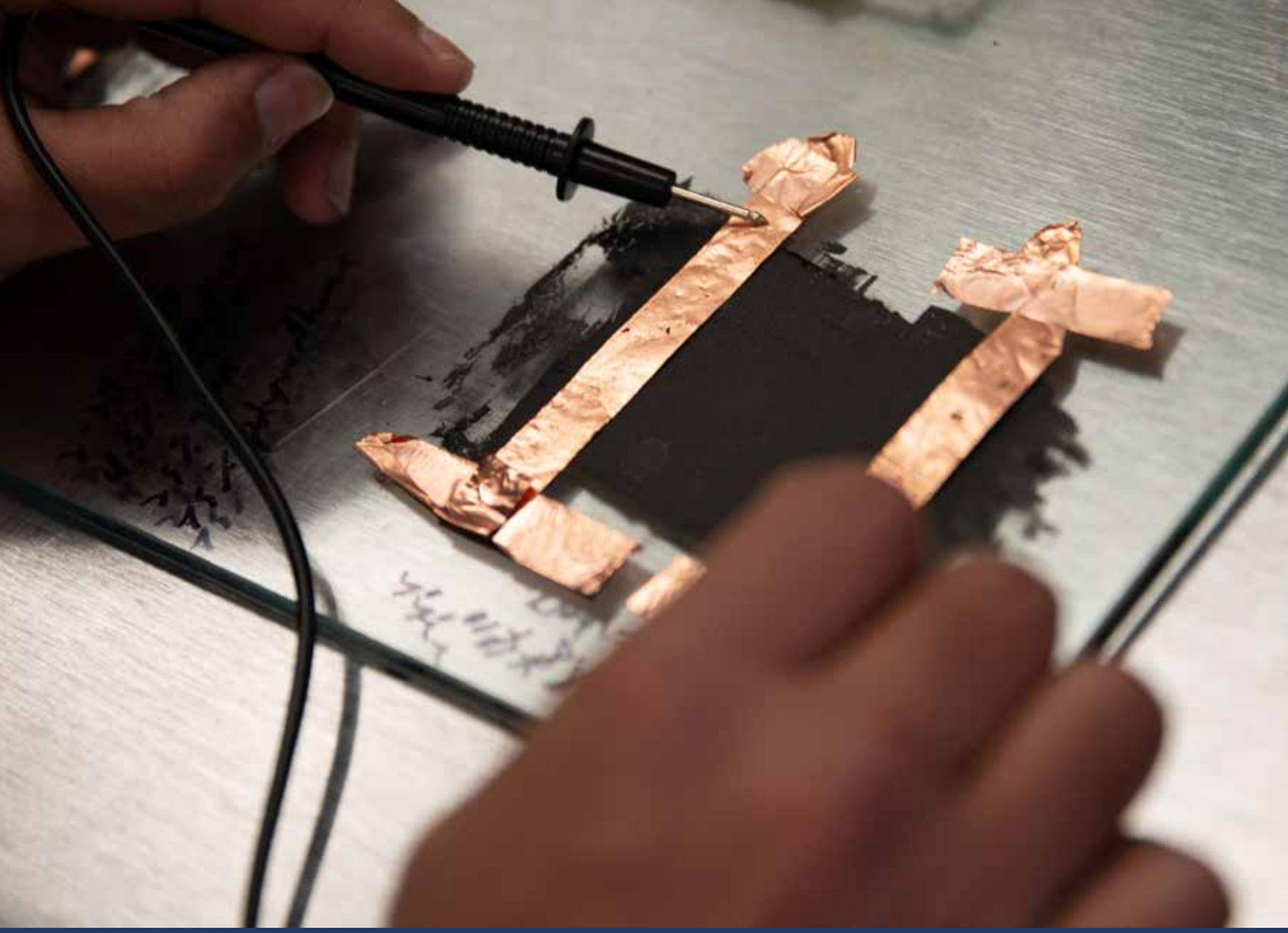
Dr. Hong's research collaboratively develops applications of molecular nanomaterials and demonstrates superior physical properties based on our patented and licensed intellectual property. This is being done using well dispersed nanomaterials to generate unique physical properties for applications such as batteries, polymer composites, sensors, 3D printing, magnets, OLED anodes, etc.

Recently, we have found around 10% thermal conductivity enhancement in very dilute nanofluids. The fluid viscosity is near water (1cp) and component concentration is around 0.01wt%. They were remarkable results . In addition, we have discovered a proximity effect in the magnetic sensitive nanoparticles of Fe2O3: carbon nanotube (1:1) samples, which indicates that Fe2O3 : carbon nanotube (1:1) shows 3-4 times higher magnetic strength than pure Fe2O3. Those exciting and abnormal results pointed towards a larger mechanism hidden inside these materials.

After careful investigation, we realized that the most reasonable explanation is related to the attachment of metal oxide particles and carbon nanomaterials by electrostatic attraction to form aggregations along the nanomaterial chain or tube wall. It was also found to be possible because of the ability to create very homogenously distributed colloidal dispersions of carbon nanotubes. This mechanism is strongly supported by the experimental results utilizing magnetic field, pH adjustment, carbon nanomaterial, surfactants, and various metal oxide types.

This is an extremely innovative approach and patent applications have been filed. Some have been issued and others are still pending. They represent a significant step forward and are an enabling technology for making better use of these materials to realize their full potential.

We would like to continue development of this promising technology and work to get the technology out of the lab and into full-scale implementation, commercializing the technology under a newly-formed majority owned subsidiary called Novum Nano. The goal is to develop, as broadly as possible, the applications based on this novel concept at an affordable cost with an ability to be scaled for large volume manufacturing.



Dr. Haiping Hong has more than 25 years of research experience with carbon nanomaterials, polymer composites, organic light emitting diodes and self-assembly techniques. During the last ten years, he has focused on carbon nanomaterial related applications such as optoelectronics, OLED, etc. Dr. Hong received his PhD in Materials from Hebrew University of Jerusalem, Israel in 1998. He has worked as a research scientist at SD Mines from 2003 to present, from level I to level IV. Before joining the SD Mines, he worked as research scientist (engineer) in the Silicon Valley startup companies Sipix & Litrex.

Dr. Hong has been awarded eleven US patents, with four pending, and two in draft. He has published more than 120 papers in peer reviewed journals and 6 book chapters. He also has given 49 oral presentations at national and international conferences. His papers have been cited more than 3150 times according to Google Scholar. He is editor of the Journal of Nanofluids, guest editor for the Journal of Nanofluids & the Journal of Nanomaterials special issues. As PI or co-PI, he has been awarded more than $6 Million from organizations such as ARL, AFRL, NASA EPSCOR major and seed research grants, DOE EPSCoR, NSF, SD state 2010 center, private industry, etc. Dr. Hong has also served as a visiting scientist for the Georgia Institute of Technology and NASA Ames Research Center. He acted as panelist for NSF thermal program and SBIR/STTR and as a reviewer for DOE ARPA-E. He co-chaired the Carbon Nano Materials and Applications Workshop held on campus as SD Mines in 2011.

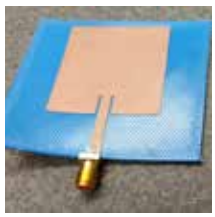
Research – Antennas and wireless communications: from precision agriculture to space technology

Dr. Sayan Roy | Antennas and Wireless Communications Research (AWCR) Laboratory

The concepts of electromagnetic wave and energy, including wireless communication, were very rudimentary until the beginning of 19th century. In 1909, Braun, a German physicist, and Marconi, an Italian inventor, were awarded the Nobel prize for their successful demonstrations of controlling the direction of radio signals using phased array antennas and establishing transatlantic wireless communication, respectively. Today at SD Mines, the Antennas and Wireless Communications Research (AWCR) laboratory is dedicated to the advanced research on novel antennas and contemporary wireless communication methods for applications in such fields as additive manufacturing, automotive, healthcare, Internet-of-Things (IoTs), precision agriculture, space technology, and wireless power transfer. The AWCR lab is physically located on the second floor of the EEP building at SD Mines.

As a director of the AWCR lab, I am very excited to have this opportunity to share our research activities with you. We continuously assist, collaborate, and work with undergraduate students, graduate students, researchers, faculties from multiple universities across the country, and federal agencies such as NASA, DoD, and DARPA. We also partner with small industries from around the world such as Raven Industries, Multi3D, Kleinfelder, and ArmaSense Wireless Solutions.

One focus area of our research is in the field of wireless body-area networks for astronauts. The environment of space is dangerous and unfriendly to humans which affects astronauts' health and mental status dramatically. Currently, NASA is interested in remotely monitoring different vitals of an astronaut's body using novel sensors and real-time wireless communications. This holistic approach to enhance the well-being of astronauts also conforms with NASA's next goal--sending astronauts into deep space exploration. This multi-university NASA project involves faculties from a multidisciplinary research background and the personnel at the AWCR lab are exploring such research aspects of this project as 1) establishing a secure, real-time, and fault-tolerant (reliable) body-area network for collecting sensor-data wirelessly and 2) modeling propagation of wireless signals from sensors inside next-generation spacesuits.



Our second focus, which naturally aligns with our first, is that of 3-D Printed conformal radio frequency circuits and sensors for space technology: In the last few years, we have successfully presented 1) a novel cost-effective and efficient way of printing radio frequency circuits using additive manufacturing technology and 2) conformal phased array antenna designs which can be integrated to any non-planar surface for wearable and vehicular applications. Currently, we are modeling and prototyping various additively manufactured sensors (strain gauges, piezoelectric) that are either exposed or embedded and either planar or conformal for incorporating into space vehicles. In the picture, you can see a 2.4 GHz patch antenna that is additively manufactured using a regular 3-D printer and a conductive material that is a non-hazardous, proprietary metal-polymer composite, consisting primarily of a biodegradable polyester and copper, and has a very low resistivity value of 0.006 Ω cm.

Apart from the above focus areas, we are prototyping and testing biocompatible radio frequency circuits for applications in precision agriculture, IoTs, and healthcare. For an example, in precision agriculture, we are currently using radio frequency circuits and antennas to sense various parameters, such as temperature, humidity, and electrical conductivity of the soil in real-time. We also investigate and address electromagnetic interference and compatibility issues in high-speed electronic circuits.

In a nutshell, there are endless possibilities arising from the research outcome of the projects happening in the AWCR lab. There is always an opportunity available to cater the needs of both students and collaborators in our research endeavors. We also seek ideas and interests from our alumni who are experts in such fields. If interested, feel free to reach us at sayan.roy@sdsmt.edu or awcr.sdsmt@outlook.com. Go Rockers!

Dr. Sayan Roy holds PhD and MS degrees in Electrical Engineering from North Dakota State University as well as a BTech in Electronics and Communication Engineering from West Bengal University of Technology in Kolkata, India. His research interests focus on real-time applications of wireless sensors and composite antennas in such fields as additive manufacturing, automotive, healthcare, Internet-of-Things, precision agriculture, spacecrafts, and wireless power transfer. Dr. Roy has co-authored 6 journal papers, 20 peer-reviewed proceedings, 1 invention disclosure, multiple research proposals, and more than 20 non-peer reviewed posters and articles. Dr. Roy was the recipient of the 2014 North Dakota State University Graduate School Doctoral Dissertation Award. Dr. Roy is currently a member of IEEE and its honor society IEEE HKN. Dr. Roy is also serving as a reviewer in multiple IEEE journals and conferences. He spends his leisure time by playing piano, fishing, and travelling with his family.

Research – Power electronics in renewable energies and transportation electrification

Dr. Malek Ramezani | Switching Power Conversion (SPC) Research Lab

The ever-growing demand for electric power, along with the shortage and environmental concerns associated with the fossil-fuel based electric power generation, has led to the development of renewable energy resources as well as green transportation electrification. Power electronics converters (PECs) are the beating heart of these developments and play a crucial role in the reliability, stability, efficiency, and cost effectiveness of these systems. The research focus of the SPC Lab is on the modeling, analysis, control design, and implementation of more reliable, efficient, and cost-effective PECs in the renewable energies and transportation electrification applications.

Renewable Energies: Increasing penetration of renewable energy resources such as solar and wind into the electric grid brings about the necessity of ensuring compatibility of their interfacing PECs to the grid code. The research in SPC Lab focuses on the development and control of central, string, and micro inverters for the integration of solar photovoltaic (PV) systems in the utility, commercial, and residential scales. The SPC Lab develops control and grid functionalities, such as low voltage and frequency ride-through, provides voltage and frequency regulation services to the grid, and interfaces inverters of renewable AC power generation systems in micro, nano, and smart grids.

Transportation Electrification: Transportation electrification involving electric vehicles, aircraft, and ships relies on the efficiency, reliability, and stability of their power conversion systems, particularly their PECs-based power trains. The SPC Research Lab develops more efficient, reliable, and stable charger and motor drive systems of electric vehicles based on the emerging technology of wide-bandgap (WBG) power devices, such as SiC and GaN transistors. The SPC also advances the control and synchronization of parallel inverters in the AC power system of electric aircraft and ships.

Malek Ramezani is an Assistant Professor of Electrical Engineering in the EE Department at the SD Mines. Prior to joining SD Mines, he held a post-doctoral research associate as well as an adjunct faculty appointment in the Engineering and Computer Science School at the Washington State University. His main research interests include modeling, analysis, design, control, and synchronization of power electronics converters in energy conversion applications, particularly in the renewable energies and transportation electrification. His current research focus is on the design and optimization of wide-bandgap (WBG) transistor-based microinverters for residential photovoltaic (PV) systems.

Staff Highlights

Marilyn Maxvold

Marilyn Maxvold, SD Mines alumnus (BS Math '75, EE '76) returned to the Black Hills following a 36 year career with the Federal Aviation Administration as a telecommunications implementation engineer. After word got out that she was looking for something to occupy some of her retirement time, she was recruited in 2015 to the EE Department by Department Head and fellow classmate, Scott Rausch. Her years in government uniquely positioned her to assist with those requirements associated with accreditation and curriculum assessment. Since that time, she has continued as a volunteer and serves as the Quality & Continuous Improvement Liaison handling such tasks as BS/MS program improvement, senior exit interviews, meeting minutes, and often serves as a community representative on faculty searches.

Leslie Prosneski

Leslie Prosneski joined the department in March 2018 as the Administrative Assistant. She was awarded the Traditions of Excellence Award in November 2018. Leslie works hard to create positive relationships with all students, faculty, and staff members. Leslie actively seeks out ways to get students involved in department activities and can often be found planning events to celebrate our department. Leslie keeps our department running smoothly, making sure faculty and students have everything they need to be successful.

Saeed Shahmiri

Saeed Shahmiri received his BS in 2016 from Amirkabir University of Technology, Tehran, Iran and his MS in Electrical Engineering in 2018 from SD Mines. He was awarded scholarships from SD Mines and was a researcher in the Robotics and Control Lab. He is a member of IEEE and has made five publications since his time at the school. Saeed joined the department as the Lab Coordinator in January 2019. As coordinator, he manages the EE laboratories, provides training for students, and assists faculty.

Student Engagement and Success

Student Clubs

To assist in the professional development of our students, the EE department encourages students to participate in the activities of professional societies such as the Institute of Electrical and Electronics Engineers (IEEE) and Eta Kappa Nu. These societies help students enhance their educational and social lives while on campus and create a network for their future professional careers.

IEEE Student Chapter

IEEE is the world's largest technical professional organization dedicated to advancing technology for the benefit of humanity. IEEE and its members inspire a global community to innovate for a better tomorrow through its highly cited publications, conferences, technology standards, and professional and educational activities. IEEE is the trusted "voice" for engineering, computing, and technology information around the globe. The IEEE SD Mines chapter strives to provide the services of a professional organization to students on campus by providing an avenue for professional development and a networking opportunity with the local industries. The IEEE club holds biweekly meetings and organizes weekly activity nights. These activity nights include soldering sessions, 3D printing sessions, and also speakers from local industry.

Eta Kappa Nu (IEEE-HKN)

IEEE-HKN is the honor society for electrical and computer engineers. The intention of the founding members of HKN was to recognize and prepare the future leaders of the profession. For more than 100 years, HKN has embraced and encouraged excellence in the profession. The Beta Chi Chapter of IEEE-HKN at SD Mines is involved in improving the skills of electrical engineering students as well as in a number of extracurricular activities. In addition, IEEE-HKN serves as a bridge or conduit between the students and the faculty.

At SD Mines, our local chapter has been involved in service activities such as academic tutoring, proctoring open laboratories, working with the High Plains Regional Science and Engineering Fair, and providing student members to university and departmental committees. In recognition for their activities, the Eta Kappa Nu Association awarded the SD Mines Beta Chi Chapter an Outstanding Chapter Award for 2005-2006 as well as Key Chapter Recognition in 2018.

Current 2018-2019 Eta Kappa Nu members

WiSE

As a department, we acknowledge that efforts are needed to provide venues for under-represented groups in the Science Technology Engineering and Mathematics (STEM) field. To support the success of our female students, we work with the Women in Science and Engineering (WiSE) center at SD Mines. The WiSE center provides opportunities for networking, outreach, and professional development for female students at SD Mines. Our EE students are encouraged to attend and participate in the events organized by the WiSE center each week. The WiSE center also invites speakers to motivate and help retain female students in STEM. The EE department strongly encourages our EE students to attend those events not only for professional development but also for networking.

Other Clubs

With 139 student organizations available at SD Mines, EE students have participated and taken leadership positions in clubs like Ham Radio Club/AKA Amateur Radio Club; 3D Print Club; Mines Martial Arts Club; Circle K International; Esports Association; Newman Club; Students for the Exploration and Development of Space; and CubeSat Team.

Corporate Engagement, Employment, Internships, and Cooperative Education

Strong partnerships with our many excellent corporate constituents are a shining strength for EE. Our graduates continue to impress their new employers, so those companies who hire from SD Mines come back year after year. Almost 160 companies came to the SD Mines fall career fair in 2019, and 97 of those sought EE students. Many more companies recruit our students remotely. Some of the qualities these recruiters value in our graduates are perseverance, ingenuity, productivity, effective teamwork, sense of economy, and an eagerness to jump in and get their hands dirty. We hear from many recruiters that Hardrockers are able to hit the ground running and learn new skills quickly, so they contribute value to their teams nearly immediately. One example is Nucor, America's largest steel producer with a keen need for EE expertise in their very power-intensive operations, who has selected SD Mines as one of just two universities to be their prime recruiting targets. Another example is L3Harris, one of the largest communications and defense contractors in the world, whose Salt Lake City division established an engagement team dedicated to SD Mines—the first of such teams they've assigned to a university outside of Utah.

Full-Time Employment. Of the 100+ companies seeking our EE graduates, almost 70 have secured our graduates in the last five years. The top five, each hiring three or more, have been Black Hills Corporation, Rockwell Collins, Blattner Energy, Burns & MacDonnell, and Garmin International. Our program produces only about 30 EE graduates each year, so the competition can be fierce! Many of our students receive multiple offers, and their average starting salary is $68,000.

Internships and Cooperative Education. Nearly 90 of the companies attending the Fall Career Fair offered internship and coop positions to our juniors and sophomores and some even recruit freshmen. About half of our students were employed in these programs last summer, and several students return to their studies with standing offers of full-time employment when they graduate. Aside from this pipeline into future employment, our students gain incredibly valuable skills that augment their studies—many students say their coop experiences were the best part of their education, and many choose to take multiple assignments during their academic careers. A small, but growing, group of local companies hire students on a part-time basis during the school year as well, and some graciously invite students in some of our classes to tour their facilities: notably B9Creations, Black Hills Energy, Darceo, FourFront Design, Littelfuse, Phase Technologies, Sanford Underground Laboratory, and VRC Metal Systems.

Scholarships, Equipment, and Project Sponsorship. Many of our corporate partners have chosen to take an even more integral role with us by providing financial and technical support for research experiences. Several companies sponsor senior design projects, volunteering time from their personnel to provide technical advising in addition to funding for equipment and supplies. See the article on senior design projects to learn how companies like Cobham, GenPro Advanced Technologies, L3Harris, Mastel Precision Surgical Instruments, Raven Industries, and Wright's Shed Co. have committed to enriching our students' educations in this fashion. We are always thankful to our scholarship and equipment donors who benefit all our students, including recent gifts of equipment from L3Harris and Phase Technologies.

The support of our corporate constituents has powered the EE department through the last century, and we will stride forward with them into the next!

"I had a co-op with Cargill in Blair, Nebraska at their corn milling plant. While there, I assisted in maintaining the electrical distribution system and planned for temporary power during planned electrical outages. This helped me realize that this kind of work is exactly what I would like to be working after graduating and made me feel good about my choice to be an EE."

~ Ethan Unruh

"I was on co-op with TDK Hutchinson Technology Inc. in Minnesota for about 7 months. While my full time job would be in a different focus area of EE, my experience on the co-op taught me a lot about the rigor and nobility of the engineering profession. It also made me value the two most important traits for engineers; ethics and problem solving skills."

~ Ishaan Shetye

Alumni – You Are a Key to Student Success

The role of our Alumni is a critical one in helping the EE department continue to produce qualified BS and MS graduates who can move into their profession and fulfill our mission to educate electrical engineering students who address global challenges, innovate to reach their creative potential, and engage in partnerships to benefit society. There are many opportunities available for you, our alumni, to directly influence and support the work of the EE department. We encourage you to consider how you can help to pass on the educational experience you received at SD Mines. Below are some of the ways available to alumni to help. We encourage you to consider any of these opportunities or contact us with your ideas on new ways for us to help students.

Alumni Impact on EE Students through Scholarships

Most college students find it necessary to supplement their personal and family financial resources in order to attend college. As a result, well qualified students in the STEM fields often must weigh their college choice based upon economic factors vs educational quality. Our department is committed to providing the outstanding engineering education which has long been the hallmark of an SD Mines degree. However, we also understand that scholarship availability can often be the deciding factor for our students. All SD Mines undergraduate students are considered for merit-based scholarships once they've been admitted to SD Mines. Along with the university scholarships, the electrical engineering department awards scholarships to new, returning, and transfer students based on each scholarship's criteria. These EE awards (over $90K in departmental scholarships in 2018) have been generously provided by our Alumni and Industry donors and help make a critical difference in our ability to attract the best and brightest students to our program. We continue to need your help as we move forward and hope that our alumni will continue their financial support of our future EEs.

Below are what some of our current students have to say about the scholarships they received from SD Mines.

"I've been able to experience so many great things in my time in college. From building a radio, to living in Chicago, all of my experiences from college all came from what I've learned in my classes and the opportunities that SD Mines sets up with career fairs. The EE department has helped support my studies with multiple scholarships as well, which has helped ease the financial burden of obtaining a degree (even though Mines tuition is incredibly reasonable in comparison to other schools). Overall, Mines has helped me grow exponentially as an individual, and the people I've met through my department have be a key part of that process."

"I cannot express how grateful I am to receive this award; it is going to help me tremendously as I pursue my Electrical Engineering degree here at SD Mines. The choice to come to Mines was simple for me. The quality education, opportunity to participate in athletics, and continue the Mines tradition in my family made it hard to pick against SD Mines. I am enjoying my time here so far, including what I have learned in the classroom. I find satisfaction when I can connect the material I learn in class to things and applications in the real world. In the future, I plan to pursue a master's degree from Mines in electrical engineering with a focus on either control systems or communications."

"Thank you again for your support. It has lightened my financial situation. I promise that this will be put to good use. I hope one day I will be able to help students achieve their goals just as you have helped me. "

" So far I have enjoyed virtually every class I have been in and am looking forward to the challenging classes ahead. This year has been my most challenging year so far. This scholarship award will help relieve the stress of worrying about paying for my next year of college and will allow me to focus on my classes. Thank you so much for helping me achieve my goals."

"In today's world, a degree is many times what determines the level of success that an individual can achieve during his or her career. In addition to representing the knowledge and expertise gained, a degree also demonstrates that an individual has the perseverance and work ethic to complete a task—no matter how long and difficult. In many senses, a degree is a key that allows its holder to open up the world so that he or she can live a successful life and be empowered to make a positive impact. Your gift has allowed me to take the next step on this path. Your gift not only assists me financially, but also serves as encouragement and motivation for me to continue working with dedication. Thank you again for your generosity. I hope that you will have a blessed year and that you will continue to support this school and its students."

Alumni Impact Thru Professorships

Edwin E. Clark Professorship in Power and Energy

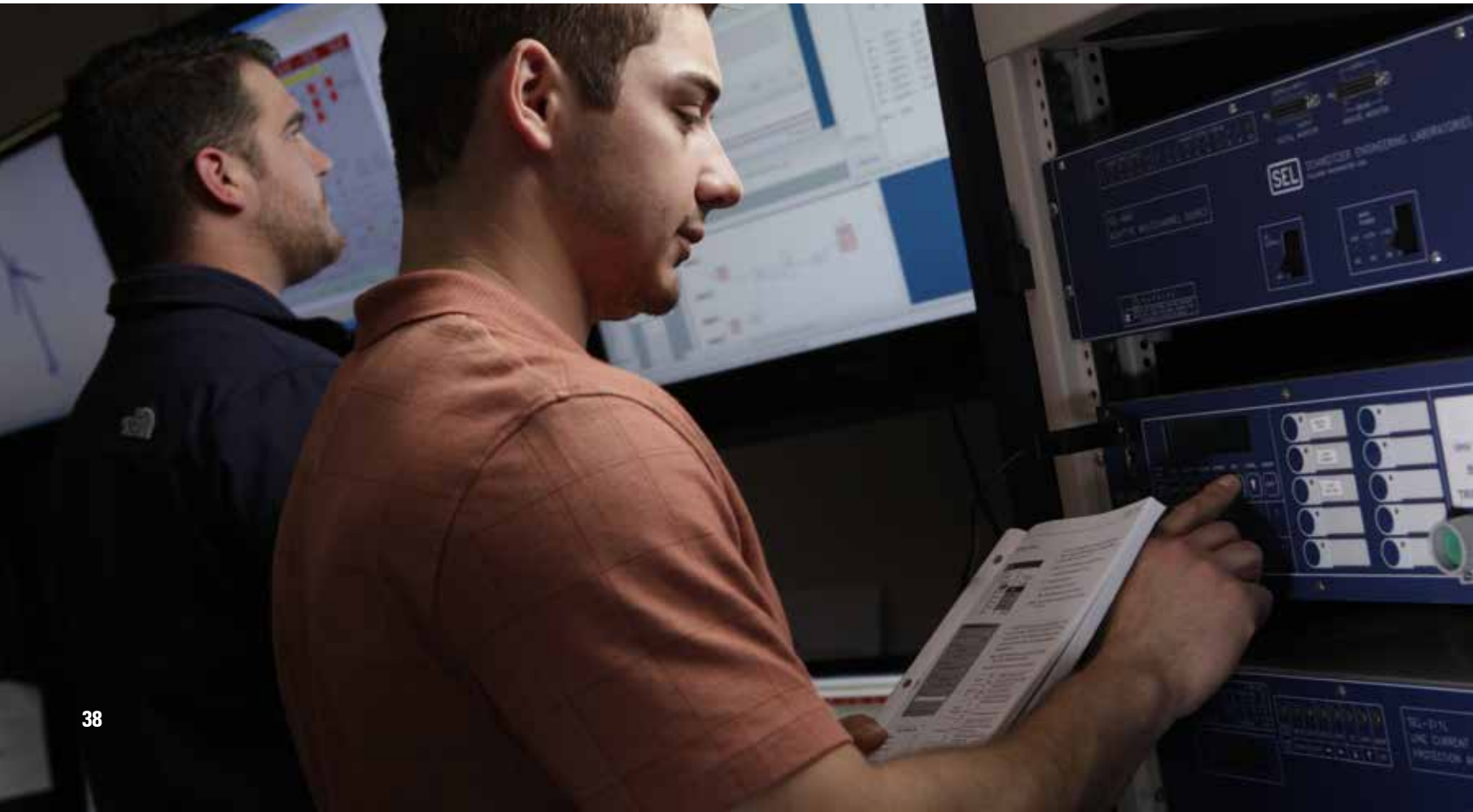
The Edwin E. Clark Endowment was established by a group of dedicated SD Mines alumni with Electrical Engineering degrees who recognized the importance and benefits that having Chair positions within the Electrical Engineering Department can provide to both the students and the institution. The purpose of this fund is to provide assistance for broadening and enhancing the Electrical Engineering Department through support of an Electrical Engineering faculty member with power and energy expertise. Dr. Malek Ramezani, Assistant Professor of Electrical Engineering, currently holds the Edwin E. Clark Professorship in Power and Energy.

William J. Hoffert Professorship

The William J. Hoffert Professorship was established by James K. and Marian K. Fawcett to honor her father, William J. Hoffert (EE'33), and benefit the Electrical Engineering Department at SD Mines. The purpose of this fund is to assist the Electrical Engineering department by supporting eminent scholars who will contribute to the Electrical Engineering Department and are able to attract outstanding graduate and undergraduate students.

Steven P. Miller Endowed Chair

The Steven P. Miller Endowment was established in 2000 to benefit the Electrical Engineering Department at SD Mines. Mr. Miller (EE '69) spent his 35 year career in the telecommunications industry culminating as the chairman of a multimillion dollar telecommunications company. In his desire to give back to the university that educated and prepared him for his successful career, he established the Steven P Miller Endowed Chair. By establishing this endowed chair in Electrical Engineering, Mr. Miller expressed his hopes that "future generations attending SD Mines can benefit from a unique educational experience through exposure to a distinguished university faculty member." The purpose of this fund is to aid with broadening and enhancing the Electrical Engineering department by supporting eminent scholars who perform research in telecommunications areas . The chair has been vacant since 2018 with searches occurring on a regular basis.



Alumni Involvement Via the Industrial Advisory Board

The most useful and reliable source of employer input is our Industrial Advisory Board (IAB), which has been in place and meeting since the early 1990s. The board consists primarily of EE department alumni from local and regional companies but also includes several non-alumni from industry and government. The IAB members who are alumni are truly dedicated to the SD Mines and the department and have tended to support the department financially and with equipment donations. We schedule two formal meetings per year, the fall and spring meetings coincide with our Senior Design fairs, so that IAB attendees can see the senior design projects and meet our seniors then and can make an assessment of the comprehensiveness, completeness, and complexity of our senior projects. A typical meeting has 10 or 12 physical attendees, with 3 to 5 persons attending via conference call. Standard agenda items include such topics as a review of department objectives, departmental highlights/accomplishments/challenges, and a curriculum review. Discussions of these topics with our IAB members is one of the primary ways the department stays abreast of the electrical engineering profession. With the recent restructuring of the department to an electrical engineering focus, we are interested in hearing from alumni who would consider being a part of this impactful group.

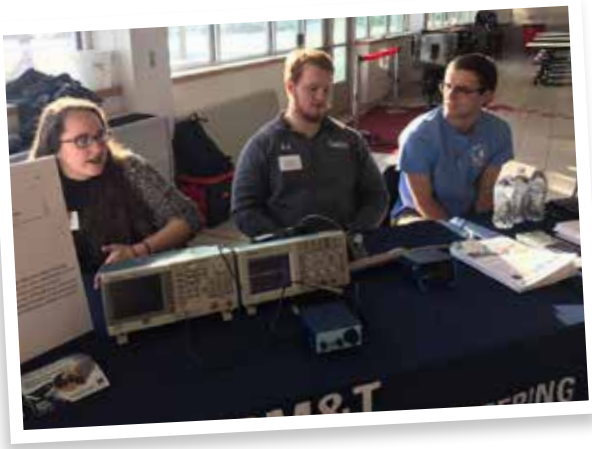
Alumni Impact Through Corporate Advocacy

Upon graduation from SD Mines, alumni have the opportunity to assist the EE students in numerous ways throughout their careers. It is common to see our new alumni return with their new employers to assist with the interview processes associated with our Career Fairs. Alumni also can serve as advocates within their companies to provide internships, provide in-kind donations (e.g., equipment/hardware) or financial assistance, and sponsor senior design projects.

Departmental Outreach Events

The electrical engineering department participates in several outreach programs throughout the year. Some are sponsored by SD Mines and other events are for community support.

High School STEM teachers and SD Mines Admissions visit EE on 2/5/19 spending the morning participating in a circuits class and Mechatronics Lab.



4th Annual STEM Career Fair was held at Rapid City Central High School this year. The EE department took part in this career fair where we showcased where a degree in electrical engineering can take you. Hands-on demonstrations were conducted for potential students to give them a feel of what electrical engineering involves. In addition, we encouraged them to schedule a personal tour with our department. Some of our current seniors were on hand to talk to the high school students about the opportunities they've had with internships and co-ops and what being a student at SD Mines is like.

Engineering and Science Day, has around 500, 6th-12th grade students come to campus to explore engineering. These students participate in hands-on demos and learn about electrical engineering classes, labs and the research that our faculty are currently engaged in.

Go to Mines events are held throughout the year for students and families wanting to learn more about engineering and which engineering field fits their interests. Go to Mines (GTM) is set up like a career fair where students learn about all engineering majors and walk around to different booths to learn what each major entails. During these events, students can sign up to tour our department and learn in more detail about electrical engineering.

Women in Science and Engineering holds a conference on campus for girls in middle school to try hands-on demos at booths from every department on campus at SD Mines. Electrical engineering faculty and staff demonstrate coding, circuits, robots and drones with some hands-on opportunities for the young girls to experience the different aspects of electrical engineering.

Holiday events with our students are planned throughout the year, including a Halloween party complete with a costume contest; a Winter Holiday party; and a Spring Social. We frequently serve fresh popped popcorn, and donuts on select mornings. Also, Leslie is always known to have goodies available in the main office.

Robotics Camp for high school junior and senior students was held in the summer of 2019. These campers learned coding and basic circuitry to build an autonomous robot for a competition at the close of the camp. Campers also had an opportunity to go on an industry tour or hear guest speakers talk about their experiences as an electrical engineer.

Student Success is our Goal!

The Electrical Engineering (EE) department at the South Dakota School of Mines & Technology (SD Mines) is committed towards the academic and professional success of our students. In addition, our department has high expectations from our graduating students. Mines graduates are expected to be successful in their chosen professions. The EE department, in addition to its cutting-edge curriculum, provides various opportunities for student and alumni success.

As a department, we know that getting a degree in EE at SD Mines is not an easy task. It requires a lot of hard work and determination. We know our students are exceptional and committed towards their academics, but if they need help regarding their coursework, our EE faculty practice an open door policy to help students in need. In addition to our faculty, we have appointed exceptional EE students as EE tutors. These tutors can help students with a variety of coursework. These tutors are committed and available to provide assistance to the students in need.

As an EE graduate, students are expected to work with diverse teams and foster inclusive environments to solve real-life problems. To achieve this, during their academic journey they are expected to enhance their interpersonal and professional skills. In the EE department, students are encouraged to participate in extracurricular and co-curricular activities. They are also encouraged to expand their networking skills as well as their professional communication skills. We hope that with all these resources, we are preparing electrical engineers who will be ready to take on real-life challenges and be successful in their profession.

Department Highlights & Statistics

- 148 Undergraduate student enrollment
- 18 Graduate student enrollment
- 900% Growth in Accelerated MS program
- 24th Top ranking MS EE program

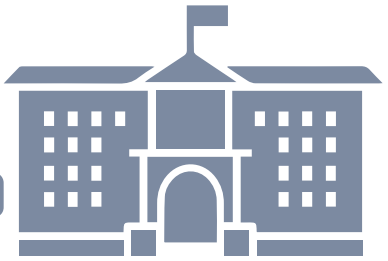
BS EE Program Differentiator
UG Research, Hands-on, Job Ready, Service Learning, Entrepreneurship

- **New EE PhD program proposal**
- **3 New Minors (Electrical, Electronics, and Systems Engineering)**
- **2 New hands-on Freshmen classes for EE's**

SOUTH DAKOTA SCHOOL OF MINES & TECHNOLOGY

3,192 degrees awarded in last 100 years

137 awarded in the last 5 years



State of the Art Facilities
Newly Renovated Circuits Labs, Power lab, Robotics Lab etc.

SOUTH DAKOTA
SCHOOL OF MINES
& TECHNOLOGY

501 E. Saint Joseph St.
Rapid City, SD 57701