



CSM Electrical Engineering—Message from the Engineering Division Director

Engineering has historically been a field that applies scientific knowledge to the needs of society by producing technological devices and systems. As the complexity in our society grows along with improvements in lifestyle and an increase in world population, technology becomes imbedded more deeply into the fabric of all of our lives. For the engineer this translates directly into technology-based demands, opportunities and challenges.



Graduate education is increasingly critical to today's engineer as the technologies that are addressed become more complex and the toolset used to analyze problems and produce solutions becomes more technically and computationally intensive. What was a solitary endeavor at a computer, a drafting table, or a work site has become a team activity requiring diverse interdisciplinary skills.

Today's engineers must be aware of modern techniques of measurement, analysis, and interpretation. They should be able to exploit sophisticated control systems and instrumentation, be familiar with advanced numerical modeling techniques and recent developments in engineering software and computer architecture, and have a good knowledge of data acquisition, processing, and visualization methods.

The Engineering graduate degree structure at Colorado School of Mines builds upon the foundation of an undergraduate engineering degree to produce a highly capable engineer with these qualities and specialization in the field of his or her choice.

The graduate program in Engineering at Colorado School of Mines offers a range of degrees to reflect the diversity of student ambitions and needs. Degrees are offered in Engineering with specializations in Electrical, Civil, Mechanical, or Systems Engineering; Systems Engineering is constructed to provide an interdisciplinary element while facilitating the specialization that is critical to a graduate endeavor. Master of Science (M.S.) degrees are offered in both thesis and non-thesis formats according to student needs, while the traditional Doctor of Philosophy (Ph.D.) degree emphasizes the classic depth of knowledge associated with state-of-the-art research.

Areas of specialization within the Engineering Division are centered around the Electrical, Civil, and Mechanical disciplines with significant research activity that spans more than one field. Significant research areas are energy and power systems, biomechanics and engineering, energy conversion and fuel cell development, controls and control systems, mechanics and nano-mechanics, geotechnical engineering, and structural engineering.

The strength of the education provided by the Colorado School of Mines Engineering Division comes from the faculty and the teaching and research interaction that they provide with graduate students. Any member of the faculty will be glad to talk with you regarding your educational aspirations and plans, and I would be happy to answer any questions that you might have. Please come and visit the Engineering Division at Colorado School of Mines as you consider the next step in your education.

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CSM Electrical Engineering—Research Overview

Within the Electrical Engineering specialty, there are two overlapping research emphasis areas: (1) Sensing, Communications, and Control; and (2) Energy Systems and Power Electronics. Many faculty in Electrical Engineering conduct research that is highly interdisciplinary and collaborative in nature.

Sensing, Communications and Control

Research in this area includes problems in robotics, mechatronics, intelligent structures and geosystems, signal and image processing, energy and power, materials processing, telecommunications, bioengineering, mining and construction. Participating graduate students come from a variety of backgrounds.

Energy Systems and Power Electronics

Research in this area emphasizes industrial issues associated with power, power electronics and renewable energy systems. Research and teaching embrace intelligent control systems, fuzzy control, real-time monitoring and advanced diagnostic systems, transformer and breaker monitoring, smart substations, power quality, advanced power electronics, and remote sensing, security, and control.

Example projects in Electrical Engineering:



Autonomous Vehicles

Architectures and control algorithms for autonomous ground and aerial vehicles.

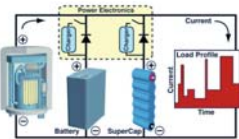
Wireless Sensor Networks

Smart antennas for robotic mobile ad-hoc networks.



Power Electronics

Electronic processing of electric power with semiconductors and signal processing.



Automated Welding

Advanced computer-vision based process monitoring & control.



Power Systems

Electric power flow, energy generation, transportation and distribution.

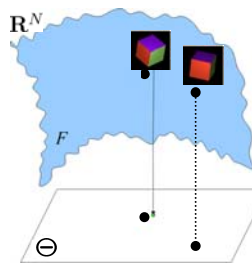
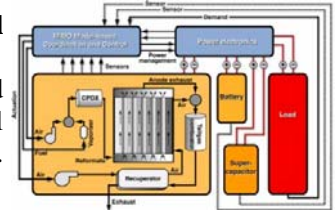


Wind and Renewable Energy

Adaptive control of utility-scale variable speed wind turbines. Control of small wind turbines with innovative drive trains.

Fuel Cell System Control

Integrated control system based on physical and computational dynamic models.

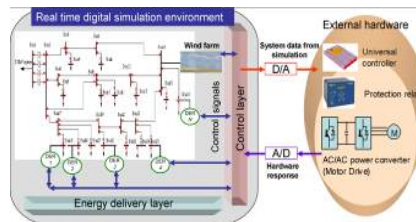


Compressive Sensing

High-resolution data acquisition using randomized low-rate measurement systems. Mathematical models for signal and image processing and for signal recovery from partial data.

Augmented Virtual Reality

Real-time 3D display overlaying real-world image with properly aligned synthetic geometry.



Customer-driven intelligent microgrids

Distributed power generation across a network of customers.

Climate Change

Studying the impact of climate-change on power distribution systems.



Iterative Learning/Repetitive Control

Control of processes that repeat the same operation over and over, such as robotic manipulators, intelligent soil compaction, and multi-pass welding.



CSM *Electrical Engineering*—Admissions, Financial Aid, and Degree Programs

The Division of Engineering offers a Master of Science and a Doctor of Philosophy in Engineering with specialties in Electrical, Civil, Mechanical, or Systems Engineering. The MS degree (thesis or non-thesis option) requires 30 credit hours of coursework and/or research. The Ph.D. program requires 72 credit hours of coursework and research, as well as the successful completion of a qualifying examination and the authorship and defense of a Doctoral Dissertation.

All doctoral students must pass a qualifying examination, which is intended to gauge the student's capability to pursue research in Engineering Systems. Normally, Ph.D. students will take the qualifying examination in their first year, but it must be taken within three semesters of entering the program.

Admissions/Entrance Requirements

The requirements for admission to the graduate studies program are a baccalaureate degree in engineering, computer science, a physical science, or math with a grade-point average over 3.0/4.0; a GRE score of 650 (math) or higher; and a TOEFL score of 550 or higher (paper based) or 213 or higher (computer based) for applicants whose native language is not English. Applications from an engineering program at CSM are not required to submit GRE scores. Transfer credit may be awarded for previous graduate-level coursework; undergraduate remedial coursework may be required to overcome technical deficiencies. Applications for admissions are accepted for both Fall and Spring enrollment; for more information and to apply online, please see Colorado School of Mines Office of Graduate Studies' webpage: http://www.mines.edu/graduate_admissions

Transfer credit can be awarded for previous graduate level coursework or an earned research based master's degree upon approval of the Division.

Financial Support

Financial aid is available to outstanding students through student teaching assistant (TA) and research assistant (RA) positions. TA and RA contracts typically include full coverage of tuition, fees, health insurance, and a stipend. Awarding of all TA and RA positions are handled by the Engineering Division in conjunction with the admissions review process. The Application for Admission as found on the Graduate Studies website includes a section regarding interest in financial support; notification of financial awards is usually done at the time of admission notification.

Federal and CSM student loans are also available to give graduate students additional funding beyond any assistantships and fellowships they might receive. For more information, see http://www.mines.edu/Admin/fin_aid

Western Regional Graduate Program

The M.S. and Ph.D. programs in the Division of Engineering are participants in the Western Regional Graduate Program (WRGP). This program offers students access to many high quality graduate programs at reduced costs. In most cases, WRGP students pay tuition at resident student rates. Students with residency in Alaska, Arizona, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, North Dakota, Oregon, South Dakota, Utah, Washington, and Wyoming are eligible to participate in the WRGP. Students do not have to meet specific financial criteria, but they must meet all admissions requirements and deadlines set by CSM. All students who indicate residency of one of these states on the admission application will automatically be included in this program.

Course Offerings

Within the Electrical Engineering specialty, there are two emphasis areas: (1) Sensing, Communications, and Control, and (2) Energy Systems and Power Electronics. Students are encouraged to decide between the two before pursuing an advanced degree. Graduate students are required to complete a set of core coursework to prepare them for experimental and theoretical aspects of research in Electrical Engineering. Additional courses are then selected from approved Electrical Engineering Technical Electives. A selection of current graduate-level courses is listed below:

- 504 Seminar on Sensing, Communications, and Control
- 504 Seminar on Energy Systems
- 510 Image and Multidimensional Signal Processing
- 511 Digital Signal Processing
- 512 Computer Vision
- 513 Wireless Systems Design
- 516 Microwave Engineering
- 514 Advanced Robot Control
- 515 Mathematical Methods for Signals & Systems
- 517 Advanced Control Systems
- 518 Robot Kinematics and Control
- 519 Estimation Theory & Kalman Filtering
- 521 Mechatronics
- 580 Electric Power Quality
- 581 Modern Adjustable Speed Electric Drives
- 582 Renewable Energy & Distributed Generation
- 583 Advanced Machine Dynamics
- 584 Power Distribution Systems Engineering
- 585 Advanced High Power Electronics
- 586 High Voltage AC and DC Power Transmission
- 587 Intro to Power Systems Market Operations
- 589 Design and Control of Wind Energy Systems
- 598 Energy Systems Stability
- 617 Intelligent Control Systems
- 618 System Identification and Adaptive Control
- 619 Applied Intelligent Control and Failure Diagnostics
- 683 Computer Methods in Electric Power Systems



CSM *Electrical Engineering*—List of Faculty



Ravel Ammerman Dr. Ammerman specializes in undergraduate education and conducts research in the areas of electrical safety, computer applications related to energy systems, and engineering education. Dr. Ammerman is the co-project manager for the IEEE/NFPA Arc Flash Collaborative Research

and Testing Project.

Sanaa Azim: Circuits, Electronics, Control

Thomas Grover Professor Grover is the administrator for the Multidisciplinary Engineering Laboratory courses and teaches several laboratory courses in the electrical engineering speciality. He assists graduate students with electronic circuit development for their research and is a research consultant for the Mining Engineering and Metallurgy Departments.



William Hoff Dr. Hoff's research interests include computer vision and pattern recognition, with applications in robotics, video aided navigation, medical imaging, activity recognition, and augmented reality.

Kathryn Johnson Dr. Johnson's research interests focus on control systems, particularly applied to wind energy. Her recent projects have examined ways to reduce the cost of wind energy by using control to increase the energy captured without increasing system cost.



Kevin Moore Professor Moore is the G.A. Dobelman Distinguished Chair and Professor of Engineering. He is a well-known researcher in the areas of autonomous control and robotics, with a particular focus on the subject of iterative

learning control.

P.K. Sen Dr. Sen's research in Power Systems focuses on electric power transmission, distribution, safety, power quality, interconnection and performance evaluation.



Marcelo Simoes Dr. Simoes's research in Power Electronics specializes in in the development of intelligent applications, neural network, fuzzy logic and genetic algorithms for industrial systems and high power electronics applications for distributed energy systems.

Catherine Skokan My research interests include engineering applications of geophysics, groundwater exploration and contamination studies, especially in the arena of humanitarian engineering, curriculum development, and K-12 outreach.



John Steele Dr. Steele's research focuses on robots and intelligent machines, mining robotics, intelligent sensing systems, and machine health monitoring.

Siddharth Suryanarayanan Dr. Suryanarayanan's research interests in electric power systems include design, operation, control, and economics of sustainable microgrids; application of systems-based approaches to electric power markets; and the relationship between climate change and the electric power industry.



Tyrone Vincent Dr. Vincent's research interests are in system identification and estimation, with applications in areas such as augmented reality, video aided navigation, automated welding, and semiconductor and photovoltaic manufacturing.

Michael Wakin Dr. Wakin's research interests include sparse, geometric, and manifold-based models for signal and image processing, approximation, compression, compressive sensing, and dimensionality reduction.



Manoja D. Weiss Dr. Weiss's focus is electromagnetic waves in communication and sensing. Current projects include robot repositioning for enhanced wireless reception, development of biomedical instrumentation, and millimeterwave imaging.