WHERE DO OUR GRADUATES GO?

For our nuclear engineering students, graduating from Missouri S&T opens up a world of opportunity — Miner alumni can be found on working at top corporations across the U.S. and abroad. Among our most recent graduates, you’ll find our nuclear engineering alumni employed by the following industry leaders, to name just a few:

- Ameren
- Callaway Nuclear Energy Center
- Center for Space Nuclear Research (CSNR)
- Clinton NPP
- Consolidated Nuclear Security, LLC
- Curium Pharma
- DC Cook NPP
- Enercon
- Fluor Marine Propulsion
- Idaho National Laboratory
- Kairos Power
- Lawrence Livermore National Laboratory
- Missouri University Research Reactor
- National Institute for Standards and Technology (NIST)
- Naval Nuclear Laboratory
- NextEra Energy
- Niroave, Inc.
- Northern Technologies, LLC
- Nutherim International Inc.
- Oak Ridge National Laboratory
- Omaha Public Power District
- Curium Pharma
- Radiological Solutions, Inc.
- Sandia National Laboratory
- SHINE Medical
- Wolf Creek NPP

JOB OUTLOOK FOR NUCLEAR ENGINEERING

There are currently about 100 nuclear reactors operating in the United States, and many more worldwide. In the US, the average age of the nuclear workforce is just over 50 years – this means that many workers are within a few years of retirement. Utilities, vendors, regulators, and others are hiring hundreds of new engineers – nuclear, mechanical, electrical, chemical, and others – each year to maintain the knowledge and skill base that will be lost with these retirements. In addition to the nuclear power industry, many graduates find positions with companies like consulting firms, non-nuclear component companies, and others that support nuclear power facilities. Other students find work outside the nuclear industry where their skills are in demand including medical device manufacturers, industrial measurement manufacturers, etc. Some students continue their education in pursuit of Master of Science or Doctor of Philosophy degrees. Overall about 30% of our students continue to graduate school, another 30% enter the nuclear power industry in some capacity, and the other 40% enter careers with other corporations.

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WHAT DO NUCLEAR ENGINEERS DO?

Nuclear engineers develop and promote the utilization of energy released from nuclear fission, fusion, and the decay of radioisotopes. Currently, there are about 100 nuclear power plants operating in the United States producing about 20 percent of our nation’s electricity. These plants use nuclear fission to produce energy and are cooled by ordinary (light) water, hence the name, Light Water Reactors. This technology produces about 60% of our nation’s carbon-free electricity, reduces the emission of greenhouse gases like carbon dioxide significantly, and contributes to a cleaner environment. In addition, nuclear reactors are used for the propulsion of submarines and aircraft carriers. In fusion power plants, under development, strong magnetic fields contain a plasma fuel of hydrogen isotopes, such as deuterium, at temperatures hotter than the sun. The deuterium extracted from one gallon of water could produce as much energy as burning several hundred gallons of gasoline. Radioisotopes are used in industry and research, and in medicine for diagnostic and therapeutic purposes. The medical use of radioisotopes and X-rays saves hundreds of thousands of lives every year throughout the world. Radioisotopes are also used in small power generators for space flights.

If you choose nuclear engineering, you could work in the areas of nuclear reactor design, plant licensing, plant operation, fuel management and development, radioactive waste disposal, health physics, instrumentation and control, fusion research, space nuclear power, and applications of radioisotopes in industry, medicine, and research. As a nuclear engineer, you might be employed by utilities, reactor vendors, architect-engineering firms, consulting firms, medical device manufacturers, industrial research centers, national laboratories, government agencies or universities.
WHY STUDY NUCLEAR ENGINEERING AT S&T?

The Nuclear Engineering (NE) program is offered under the department of mining and nuclear engineering. The primary mission of the NE program is to provide an outstanding and comprehensive education to tomorrow’s leaders in nuclear science and technology. The objectives of the Bachelor of Science program are to provide each student with fundamental knowledge of nuclear engineering and related technologies, analytical and problem solving ability, ability for technical communications, professional ethics, leadership and interpersonal skills, capability to conduct research, and the ability to recognize the value of and pursue life-long learning.

The NE program provides well-educated nuclear engineering professionals and leaders to Missouri and the nation, in the commercial nuclear industry, national laboratories, hospitals, graduate schools, and the nation’s defense and federal agencies. Nuclear Engineering at Missouri S&T, one of the earliest accredited undergraduate programs in the nation, interacts with professional societies, and the nuclear industry to promote continuing education, research opportunities, and public dissemination of information about issues and advances in the field.
SUGGESTED COURSE OF STUDY

BACHELOR OF SCIENCE IN NUCLEAR ENGINEERING

The nuclear engineering curriculum consists of three components: general education, mathematics and basic sciences, and engineering topics. The full plan of study is shown on page 7. The students apply the principles of physics, chemistry and mathematics to the study of engineering topics which include statics, mechanics of materials, electronic circuits and machines, thermodynamics, and metallurgy. The knowledge gained in these areas is applied to the understanding of nuclear engineering topics including reactor fluid mechanics and heat transfer, reactor physics, nuclear radiation measurements, radioactive waste management, reactor laboratory and operation, nuclear materials, and nuclear systems design (a capstone design course).

Engineering design is an integral part of a significant number of required courses in the nuclear engineering program. Design topics include but are not limited to reactor cooling systems, radiation protection, structural components, waste disposal and transportation systems, nuclear reactor cores and the design of experiments for radiation detection and measurement. While obtaining experience in these areas the students are prepared for designing a complete nuclear system such as a nuclear plant for electric power generation, space propulsion, desalination, district heating or radioisotope production for industrial, medical or research applications.

EXPERIENTIAL LEARNING REQUIREMENT

All students at Missouri S&T are required to participate in appropriate experiential learning activities. Experiential learning activities are designed to require students to go beyond mastering basic skills and knowledge in the application of that material to problem solving challenges. These activities involve collaboration and reflective learning and allow students to learn in environments that align with their aptitudes.

Examples of activities that fulfill the Experiential Learning requirement include, but are not limited to:

» Co-ops or internships
» Undergraduate research
» Participation in design competition to completion
» Study abroad program
» S&T-sponsored service learning
» Leadership positions with student organizations (ANS, NSDT, WiN).

REACTOR OPERATOR LICENSING PROGRAM

Missouri S&T is unique in that our undergraduate students have the opportunity to become licensed Reactor Operators (ROs) prior to graduation. Students will work with reactor staff, study relevant Nuclear Regulatory Commission (NRC) regulations, learn the fundamentals of how a nuclear reactor works, spend time in the control room, and take the NRC reactor operator’s exam. Some students may also have the chance to complete Senior Reactor Operator (SRO) licensing.

Students who are interested in the program should contact Ethan Taber (etaber@mst.edu)

General application deadlines:
Fall Semester - July 15
Winter/Spring Semester - December 15
Summer Session - May 1

EDUCATIONAL OBJECTIVES

1. Fundamental knowledge of nuclear engineering and related technologies: Our graduates will continue to demonstrate a sound fundamental knowledge of nuclear engineering and related technologies as members of their professional community.
2. Analytical and problem solving ability: Our graduates will continue to use logical, creative, collaborative, analytical and problem solving abilities to address emerging multidisciplinary endeavors.
3. Technical communication and interpersonal skills: Our graduates will continue to demonstrate technical communication and interpersonal skills, enabling them to excel in their profession.
4. Leadership and professional ethics: Our graduates will continue to demonstrate leadership with an understanding of, and a commitment to, professional ethics.
5. Capability to conduct research: Our graduates will continue to demonstrate the capability to conduct research enabling them to contribute to meeting the needs of their profession.
6. Pursuit of life-long learning: Our graduates will continue to demonstrate a recognition of, and a desire for, the pursuit of life-long learning that will foster their ability to adapt to change.
The Catalog states that students may transfer from Freshman Engineering to departments with up to two of the common freshman year courses not yet completed, provided departments will accept them. The following guidelines are used in evaluating applications for admission to the Nuclear Engineering degree program:

1. A cumulative GPA > 2.0

Students may take sophomore-level Nuclear Engineering courses in order to satisfy the admission requirements and re-apply for admission. However, graduation from the Nuclear Engineering program expects official admission to the program prior to beginning the Junior-year Nuclear Engineering courses.
PROFESSIONAL & HONOR SOCIETIES

AMERICAN NUCLEAR SOCIETY (ANS)
The American Nuclear Society (ANS) is a not-for-profit, international, scientific and educational organization. ANS has a diverse membership composed of approximately 11,000 engineers, scientists, administrators, and educators representing 1,600 plus corporations, educational institutions, and government agencies. It is governed by four officers and a board of directors elected by the membership.

Vision: ANS will be the recognized, credible advocate for advancing and promoting nuclear science and technology.
Mission: ANS provides its members with opportunities for professional development. It also serves the nuclear community by creating a forum for sharing information and advancements in technology, and by engaging the public and policymakers through communication outreach. Mission components can be found in the ANS strategic plan.
Purpose: The core purpose of ANS is to promote the awareness and understanding with regard to the application of nuclear science and technology.

The ANS Student Chapter at Missouri S&T is a student-led professional organization. The mission of the Missouri S&T American Nuclear Society is to promote understanding in, and advancement of, the sciences pertaining to the atomic nucleus in our community, especially those for peaceful applications. The chapter was founded in 1967. The organization creates opportunities to experience Nuclear Engineering outside of the class room and open doors to professional relationships and networking by providing the opportunity to travel to ANS conferences, national laboratories, and so on.

WOMEN IN NUCLEAR (U.S. WiN)
U.S. Women in Nuclear (U.S. WiN) is the premier network of over 8,000 women and men who work in nuclear- and radiation-related fields around the country. The U.S. WiN has following strategic objectives:
• To support an environment in nuclear energy and nuclear technologies in which women and men are able to succeed
• To provide a network through which the women and men in these fields can further their professional development
• To provide an organized association through which the public is informed about nuclear energy and nuclear technologies.

U.S. WiN members participate in networking, professional development and outreach activities through local chapters, regional organizations, and the national organization.

Membership is open to both men and women at Missouri S&T. We strive to help provide a network for members to further their professional development, inform the public about nuclear energy and technology, and encourage women and diversity to participate in the nuclear, engineering, and energy fields.

Nuclear Science Week ANS BBQ
High school students with Cloud Chambers
NUCLEAR SCIENCE DESIGN TEAM

Missouri S&T design team experience prepares students for success in whatever endeavor they may choose. These student-led teams learn the organizational problem-solving process essential for the successful development of a market-ready product. Design team members network with industry professionals and students from competing schools alike, forming personal and professional relationships that can lead to rewarding careers.

The Nuclear Science Design Team (NSDT) develops original ideas or concepts related to nuclear science and technology. Final designs or papers are submitted to national competitions, including the yearly ANS student design competition. The purpose of the organization is:

1. Research, design, and build nuclear devices
2. Participate in American Nuclear Society competitions
3. Promote technological advancement, particularly in nuclear fields
4. Expand members’ knowledge of classroom concepts
5. Increase awareness of environmental protection and health safety throughout all aspects of developing NSDT next project
6. Develop skills that will prepare members for leadership roles in industry
7. Promote cooperation between multiple scientific and engineering disciplines
8. Promote the University through ANS competitions and public outreach programs

Past projects include construction of an Inertial Electrostatic Confinement (IEC) fusor. The team is always looking for new members. All students are welcome. Any major and no experience required.
Radiation imaging has been the most successful and useful method of early cancer detection as well as a highly helpful nondestructive testing method for various industrial applications. In the ARTLAB, we are developing innovative radiation imaging systems for medical and industrial purposes. We develop and utilize a wide range of new tools, from x-ray sources for radiation imaging to sophisticated algorithms for image processing and computed tomography (CT) reconstruction. One such example is the ongoing project of developing a stationary CT for real-time 4D imaging that will be useful both in medicine and industry. For the stationary CT, a new type of x-ray tubes for fast imaging is under development. Also, we develop machine learning algorithms for radiation image analysis and automatic radioisotope detection for homeland security and defense applications. The lab is equipped with a homemade benchtop 3D CT, a clean room for x-ray tube experiment and a high-performance computer server with COMSOL software for simulation studies.

The D-D generator uses Deuterium gas and a microwave to generate plasma as an ion source to induce nuclear fusion. This results in a relatively high-flux source of fast and epithermal neutrons useful for prompt gamma neutron activation analysis, neutron activation analysis, and radiography. Using Deuterium rather than radioactive Tritium, as well as an “open-vacuum” construction, allows the system to be easily reconfigured for experiments.

The Thermal Hydraulic Experiment, Modeling, and Engineering Simulation (THEMES) Laboratory is designed as a modular, multipurpose facility capable of supporting a wide variety of multiphase flow experiments, simulations, and modeling efforts. The central feature of the THEMES Laboratory is a modular test facility designed to support up to six concurrent experiments by effectively utilizing existing infrastructure. This allows for rapid deployment of experiments, lets projects progress rapidly to the construction and testing phases, and reduces the cost to the sponsor. A 30 hp pump provides up to 1000 gpm of water flow at 90 ft of head, while a 50 hp compressor provides up to 270 acfm of compressed air at a pressure of 200 psi. Flow is measured using pressure transducers, rotameters, a laminar flow element, a vortex flow meter, a magnetic flow meter, and other state-of-the-art instruments. Robust four-sensor electrical conductivity probes for multiphase flow measurements are constructed and characterized in-house, with unique software for enhancing data processing performance.
Research and Lab Facilities Continued

Vacuum Technology and X-Ray Generation Laboratory

Located in Fulton 213 this lab has facilities to produce and work with vacuum technology up to 10-9 Torr. The equipment includes roughing mechanical pumps, ion pumps, turbo pumps, glass vacuum chambers, steel vacuum chambers with programmable ramp-heating capabilities, Residual Gas Analyzer-RGA200, and a variety of pressure gauges, ion guns, and radiation detectors and other measurement equipment. Total area is 561 sq ft.

Nanotechnology, Nuclear Forensics and Radiochemistry Laboratory

The Radiochemistry and Nanotechnology Laboratory is located in Fulton 218 and houses a fume hood with wet chemistry capabilities, a two seat glove box, chemical waste disposal, safes for radioactive materials, UV-Vis Spectrophotometer, analytical balance, centrifuges, vacuum filtration and drying system, furnace, stereo microscope, ultrasonicators, with a total area of 466 sq ft.

Nuclear Materials Laboratory

The Nuclear Engineering department is home to two laboratories with specialized equipment for characterizing the effects of radiation on solids at the atomic and microscopic scales. Equipment available includes a Confocal Raman Microscope, a Positron Annihilation Lifetime Spectrometer, a Modulated Photothermal Radiometer, a Three-Omega system configured for thermal diffusivity measurements and a Four-Terminal Resistivity Station. The facilities of the campus Materials Research Center are also available for nuclear materials related research. These facilities include state-of-the-art Scanning and Transmission Electron Microscopes, X-ray Diffractometers, a Nanoindenter, Atomic Force Microscope and X-Ray Photoelectron Spectrometer among other tools. Ample opportunities exist for Nuclear Engineering students to collaborate with students and researchers in the campus Materials Science and Engineering Department.
The Missouri S&T Reactor (MSTR) is located on the Missouri University of Science and Technology campus in Rolla, Missouri. MSTR provides facilities for experimental research, undergraduate training, and learning about reactor physics and other aspects of nuclear engineering. It is a 200 kW pool-type reactor, and is integral to the education of Nuclear Engineering students through hands-on laboratory activities. The reactor was initially licensed in 1961, and was converted from high-enriched uranium (HEU) to low-enriched uranium (LEU) in 1992.

Recently MSTR has gone through a number of changes. A new active cooling system capable of removing up to 400 kW of heat was installed using funding from the Department of Energy in 2013. In 2014 new digital control room systems were installed, replacing the original systems from 1961 and allowing MSTR to serve as a testbed for new digital reactor control technologies. A distance education system, also installed in 2014, allows our faculty and staff to provide online training through distance education for students around the world. Additional modifications are planned over the next several years, including the installation of new digital recording systems to replace paper records.

Research facilities, experimental capabilities and services available at the reactor include:

- A neutron beam port for neutron radiography, tomography and ex-core neutron irradiations
- Thermal column for experiments involving thermal neutrons
- Pneumatic transfer tubes for in-core irradiation experiments and Neutron Activation Analysis (NAA)
- Isotope production elements and void tubes for in-core irradiations
- Internet accessible hot cell facility for high-activity sample irradiation and counting
- Subcritical assembly for teaching the fundamentals for reactor physics
- Gamma spectroscopy systems equipped with NaI and High Purity Germanium (HPGe) detectors
- Liquid scintillation counter for alpha and beta spectroscopy
- State-of-the-art distance education system for broadcasting reactor labs to outside universities and organizations

Radiation Measurements and Spectroscopy Laboratory

RMSL is a teaching lab mainly for education and training of undergraduate nuclear engineering students. Three identical workstations for alpha particle, beta particle, and gamma-ray spectroscopy can provide “hands-on” training in radiation detection and measurement for 18 students at a time. The five internet-accessible digital signal analyzers allow 50 remote users to participate in nuclear spectroscopy and measurement and collection of spectra data via an internet connection at any given time. When the RMSL is not in use for education or training, it is open for faculty and graduate students to conduct research. The lab was significantly renovated with support from DOE and is equipped with state-of-the-art radiation detectors and signal processing systems.
SCHOLARSHIPS

A number of need and/or merit based scholarships or research awards are available to NE students. Female and minority students qualify for additional scholarships. Over 90% of NE students receive some kind of financial support. Sophomores and Juniors with summer work experience in the nuclear industry can receive scholarships from the National Academy for Nuclear Training (NANT). Sophomores and Juniors can also apply for American Nuclear Society (ANS) or Nuclear Regulatory Commission (NRC) scholarships for the following year. These scholarship may include service requirements, such that you must work in the nuclear industry for a certain amount of time (usually 6 months) per year of support. The following are NE-specific award opportunities:

- National Academy for Nuclear Training (NANT): $2,500/yr, renewable for 3 years
- OURE: $500-$1000/yr
- ANS Scholarships (NEED, Minority, Women): $1000-$4000/yr
- NE Program Scholarships: $500-$1000/yr
- NE Research Award: $500-$1000/yr
- NRC Scholarships: Up to $3000/yr; generally undergraduates with GPA > 3.0 qualify

The NE awards and NRC Scholarships (which are administered by the program) are awarded based on the program’s scholarship application.
NUCLEAR ENGINEERING SUMMER CAMP

IF YOU ARE INTERESTED IN NUCLEAR ENGINEERING, THIS ONE-WEEK SUMMER PROGRAM WILL INTRODUCE YOU TO THE FASCINATING WORLD OF NUCLEAR POWER AND THE OUTSTANDING OPPORTUNITIES IN NUCLEAR ENGINEERING.

» Eligibility: For rising 11th, 12th graders and graduating seniors
» Capacity: Space is limited to 40 students (if the camp is full you can request to be placed on a waiting list).
» Registration Fee: $700 (includes room and board)

Camp Experiments

» Natural Radioactivity
» Nuclear Forensics
» Reactor Operations
» Shielding

Tours

» Missouri S&T’s Research & Training Reactor
» Ameren UE’s Callaway Nuclear Power Plant
» Phelps Health medical Radiology & Oncology

Transportation Policy

» Participants must provide their own transportation to and from Missouri S&T. USA Express provides shuttle service from Lambert-St. Louis International Airport to campus. The shuttle service schedule is available online, or you can call toll free at 1-800-872-9399.
MEET THE FACULTY

AYODEJI B. ALAJO
Associate Professor and Nuclear Engineering Program Director

Areas of Interest

CARLOS H. CASTANO GIRALDO
Associate Professor

Areas of Interest

JOSEPH GRAHAM
Associate Professor

Areas of Interest

HYOUNG K. LEE
Associate Professor

Areas of Interest
Radiation Imaging (X-ray, Gamma and Neutron) and Its Application to Medicine and Industry.

XIN LIU
Associate Professor

Areas of Interest
Quantitative X-ray/Neutron Imaging, Advanced Computed Tomography Reconstruction, Image Processing, Radiation Detection, Dosimetry, Biology, Monte Carlo Simulation and Nuclear Well Logging.

GARY E. MUELLER
Associate Professor

Areas of Interest

JOSHUA P. SCHLEGEL
Associate Professor

Areas of Interest

SHOAIB USMAN
Associate Professor

Areas of Interest
JOINT APPOINTMENT FACULTY

MUTHANNA AL-DAHHAN
Professor in Chemical & Biochemical Engineering

JOHN GAHL
Professor in Electrical and Computer Engineering at University of Missouri-Columbia

JOSEPH SMITH
Professor in Chemical & Biochemical Engineering

HAIMING WEN
Assistant Professor Materials Science & Engineering

SUPPORT STAFF

DAWN DAVIS
Office Support Staff

REACTOR STAFF

ETHAN TABER
Reator Manager