MISSOURI S&T™ | Nuclear Engineering and Radiation Science

Undergraduate Handbook

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301 West 14th Street • 222 Fulton Hall • Rolla, MO 65409-0170 Phone: 573-341-4720 • Fax: 573-341-6309
Email: nuclear@mst.edu • Web: nuclear.mst.edu

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1. KEY PERSONNEL

NERS Department Chair:
Dr. Joseph Newkirk
Fulton Hall, Room 222
jnewkirk@mst.edu

NERS Associate Chair - Academics:
Dr. Joshua P. Schlegel
Fulton Hall, Room 203
schlegelj@mst.edu

Staff Advisor:
Mr. Stephen Casey
McNutt Hall, Room 230
caseysc@mst.edu

2. OVERVIEW OF NUCLEAR ENGINEERING

As new challenges arise, nuclear technology can be used to create innovative solutions. Skilled men and women are necessary to develop those solutions. As a nuclear engineer, you can look forward to a promising future in an exciting and growing field. Nuclear Engineering is a very multidisciplinary degree path with connections to mechanical engineering, chemical engineering, electrical engineering, materials science and engineering, and physics. It blends the intellectual rigor of physics with the applied design aspects of the various engineering disciplines. This helps nuclear engineers develop creative solutions and approaches to problems. At Missouri S&T, nuclear engineering students develop a strong background in engineering systems and the skills necessary to turn scientific discoveries into useful designs. They also learn how to explain their ideas, research, and projects to managers and the public. Success in the degree program requires curiosity and imagination, initiative, abstract reasoning, and the desire to succeed.

The Nuclear Engineering (NE) degree is offered under the Department of Nuclear Engineering and Radiation Science (NERS). The primary mission of NERS is to provide the next generation of engineers and leaders who will lead the way to solutions to future energy, economic, and environmental challenges through nuclear science and technology by applying research and embracing innovation and diversity. Nuclear Engineering is a strong and growing engineering program administered by highly motivated and active nuclear engineering faculty; first accredited in 1960, it is one of the earliest ABET accredited undergraduate programs in the nation and is the only B.S. Nuclear Engineering degree program accredited in the state of Missouri. Faculty interact with professional societies, national laboratories, and the nuclear industry to promote continuing education, research opportunities, and public dissemination of information about

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.

The broad background of a nuclear engineer means that graduates are qualified for a variety of careers. If you choose nuclear engineering, you could work in the areas of nuclear reactor design, plant licensing and/or operation, fuel management and development, design and testing of space nuclear power systems, naval and defense programs, radioactive waste disposal, health physics, medical isotope production, medical imaging and treatments, instrumentation and control, fusion research, and applications of radioisotopes in industry and research. You may also work on major project design and coordination, environmental remediation, 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. Potential plans of study for several focus areas are presented in Appendix B.

EDUCATIONAL OBJECTIVES

1. Our graduates will develop and effectively communicate logical, creative, and ethically sound solutions to complex engineering projects involving nuclear and other technologies while working as part of a multidisciplinary project team.
2. Our graduates will have the ability to obtain relevant professional licenses or pursue advanced degrees, developing engineering solutions or pursuing original research to continue meeting the needs of their profession and community.

STUDENT OUTCOMES

1. The ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. An ability to apply engineering design to produce solutions that meets specified needs with consideration of public health, safety and welfare as well as global, cultural, social, environmental, and economic factors..
3. An ability to communicate effectively with a range of audiences.
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgement to draw conclusions.
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

RESEARCH LABORATORIES AND FACILITIES

- 200 kW pool-type Nuclear Reactor

- Beam port
- Active cooling system
- Thermal column
- Pneumatic transfer tubes.
- Internet Accessible Hot Cell Facility
- Subcritical Pile

- D-D Neutron Generator
- Radiation Measurements and Spectroscopy Lab
- Nanotechnology, Nuclear Forensics, and Radiochemistry Lab
- Thermal Hydraulics Experiment, Modeling, and Engineering Simulation (THEMES) Laboratory
- Hydrogen and Mass Spectrometry Lab
- Nuclear Materials Lab
- Advanced Radiography and Tomography Laboratory

MISSOURI S&T REACTOR (MSTR)

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.

MSTR

EMPLOYMENT OUTLOOK

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. A list of companies that have hired our graduates over the last 10 years is included in Appendix B. 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.

Starting salaries for nuclear engineering graduates are among the highest among the various engineering disciplines, although starting salaries to vary depending on your chosen career path. Your starting salary will vary based on several factors including the location of the job and your qualifications (GPA, previous work experience, etc.). Typically, our **placement rates** are over 90%.

Internships

Internships are increasingly important for students trying to gain real-world experience and get an advantage over their competition. Nuclear engineering students from Missouri S&T have participated in internships with a wide variety of companies in the nuclear power industry and elsewhere, but certain companies like **Transware** and **Callaway NPP** (Ameren UE) specifically seek out S&T students for internships and are good places to apply. **Exelon Nuclear** hires 90 or more interns every year as well, and many of those interns go on to full-time positions after graduation. Other companies that have hired S&T interns in the past include:

- Wolf Creek NPP
- DC Cook NPP
- Kairos Power
- Center for Space Nuclear Research (CSNR)
- Clinton NPP
- NextEra Energy
- Idaho National Laboratory
- Oak Ridge National Laboratory
- Sandia National Laboratory
- Lawrence Livermore National Laboratory
- Omaha Public Power District
- Curium Pharma
- SHINE Medical
- NextEra Energy
- Niowave, Inc.
- National Institute for Standards and Technology (NIST)
- NREIP (Navy Research)

3. SCHOLARSHIPS

Need and/or merit-based scholarships or research awards are available to NE students. 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 semester of support. The following are NE-specific award opportunities:

- National Academy for Nuclear Training (NANT): $2,500/yr, renewable for 3 years
- OURE: $500 scholarships, or $2,000 for interdisciplinary fellowships
- 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
- NUPOC: full tuition and monthly stipend for students planning to serve in the US Navy

The NE awards and NRC Scholarships (which are administered by the program) are awarded based on the **program's scholarship application**. Applications are online at the Nuclear Engineering web page.

4. UNDERGRADUATE ADVISING

Students in NERS will have two academic advisors. A staff advisor will help students select courses and register each semester. A faculty advisor will be available to help students with career-related questions and other types of academic support.

Any problems that affect a student's academic performance should be discussed with either the staff or faculty advisor. He or she can provide help to resolve academic performance problems or direct the student to resources on campus. Faculty in nuclear engineering maintain an open-door policy. Whenever a faculty member's door is open, they are available for walk-in appointments. If necessary, you can always email your advisor to schedule an appointment in advance. You may also make appointments with your staff or faculty advisor to discuss department scholarships, internships and co-ops, options for taking summer classes at a local campus, undergraduate research opportunities, selecting a minor, information about graduate school programs, request a letter of recommendation, etc.

A typical pre-registration advising appointment with your staff advisor might last anywhere from 10 to 20 minutes, depending on your needs, and may proceed as follows:

- Your advisor greets you
- You discuss any concerns you have with your current course load, especially any issues that may affect your future courses
- You discuss your extracurricular activities, and any effect those may be having on your academic performance.
- You discuss the courses you plan to take next semester, where they fit into your plan of study, and any challenges those courses may present.
- You ask your advisor about any additional questions you may have (summer courses, internships, career advice, etc.)

RESPONSIBILITIES OF THE ADVISOR

Some responsibilities of our academic advisors include:

1. Post office hours and be available. Keep appointments or call/email to change or cancel them.
2. Endeavor to know his/her advisee well enough to be able to write a cogent letter of reference if requested to do so.
3. Exhibit good listening and questioning skills to identify academic and/or personal problems which may affect academic performance.
4. Discuss career options and interest as they may relate to the student being advised.
5. Assess the student's ability to successfully complete the proposed academic load and offer suggestions for modification when appropriate.
6. Be aware of campus facilities and resources which are in place to assist students and be prepared to refer students to these programs when appropriate. Offer to assist in making appointments and follow ups as appropriate.
7. Be generally aware of campus rules and procedures relating to academic matters. Examples include, but are not limited to, add/drop procedures and deadlines, change of grading option and probationary rules.
8. Be very familiar with the curriculum in which he/she is advising so that students can be assisted in a selection of courses resulting in a degree or other educational goals.

RESPONSIBILITIES OF THE ADVISEE

1. Keep appointments or call/email to change or cancel them.
2. Be prepared; write down questions and concerns that you may have.
3. Check your e-mail on a regular basis and respond to e-mails sent to you by your advisor.
4. Respond to Academic Alerts and follow the instructions. See your advisor as soon as you begin to experience academic problems.
5. Schedule a meeting with your academic advisor prior to Advising Week scheduling. Prepare for the meeting with your advisor by reviewing your degree requirements using your CAPS report available through Joe'SS.
6. Bring a proposed schedule with you to pre-registration appointments; this may not be a final schedule but provides you and the advisor with a starting point.
7. Obtain approval from your advisor for special processing such as pass/fail or hearer status using forms provided on the web for this purpose.
8. During advising, your advisor will need to remove your registration advising hold. Your appointment time for registration will be available on Joe'SS.

Coursework Requirements:

- A student must register for 12 credit-hours to maintain full-time status (6 credit-hours if registering for summer semester).
- A student can register for a maximum of 18 credit-hours in a semester, unless they have the approval of their academic advisor and submit an Excess Hours form to the registrar.

Scholastic Probation:

Students are given an academic standing at the end of each semester. For most students that standing is “Good Standing” meaning they have achieved a semester and cumulative GPA of 2.0 or above. Students who do not meet those requirements may go on probation or deficiency.

Probation-Scholastic: A student is placed on scholastic probation if his/her current semester or cumulative GPA is less than 2.000. If the cumulative GPA is less than 2.000 and the current semester GPA is above 2.200, the student will not be placed on probation. A student on probation is restricted to 13 credit hours and may not hold office in any organization.

Deficiency-Scholastic: A student is scholastically deficient if he/she has two or more semesters of scholastic probation. Also, he/she is immediately considered scholastically deficient at the end of any semester in which he/she has one or more "U" or "F" grades and no grade higher than a "D". The student’s records will be referred to his/her academic department for a decision on continued enrollment at Missouri S&T, with the results forwarded to the student by the Office of the Registrar. Students can appeal denied enrollment by the department to the provost. Students that have preregistered and paid fees will be allowed to keep their schedule, with appropriate modifications, if readmitted to the University.

When students experience academic difficulty in a course they have several options:

1. Remain in the class and utilize the academic resources that are provided on campus. Visit with the professor, form study groups or partners for the course and increase the dedicated hours of study time.
2. Hearer Status: Students are required to pay full fees for classes in which they register as a “hearer.” None of the work will be graded and the student is not entitled to credit in the course. The student is required to attend class and may receive a “WD” grade if attendance is not to the satisfaction of the instructor of the class. The course credit will be included in all certifications of enrollment. Hearer status must be declared prior to the end of 6-weeks of class.
3. Dropping the course: It may be recommended to drop a course rather than change to hearer status if the student is struggling in multiple courses and needs to dedicate more time to other classes or if the student may not need the course. No courses can be dropped in the last three weeks of class or during finals week. No transcript record is made if the course is dropped within the first six weeks; a "WD" is posted on the transcript if dropped after six weeks.

Students who have gone deficient may be denied readmission by their departments. If that happens, a student may apply for readmission to the Undergraduate Advising Office on a temporary basis as an undecided student. The Undergraduate Advising Office has dedicated full-time advisors to assist students in turning around their academic status; they offer resources and

guidance on success. The goal is to increase the students' GPA's so that they may apply for readmission to the department.

5. PLAN OF STUDY

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 the next page. 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.

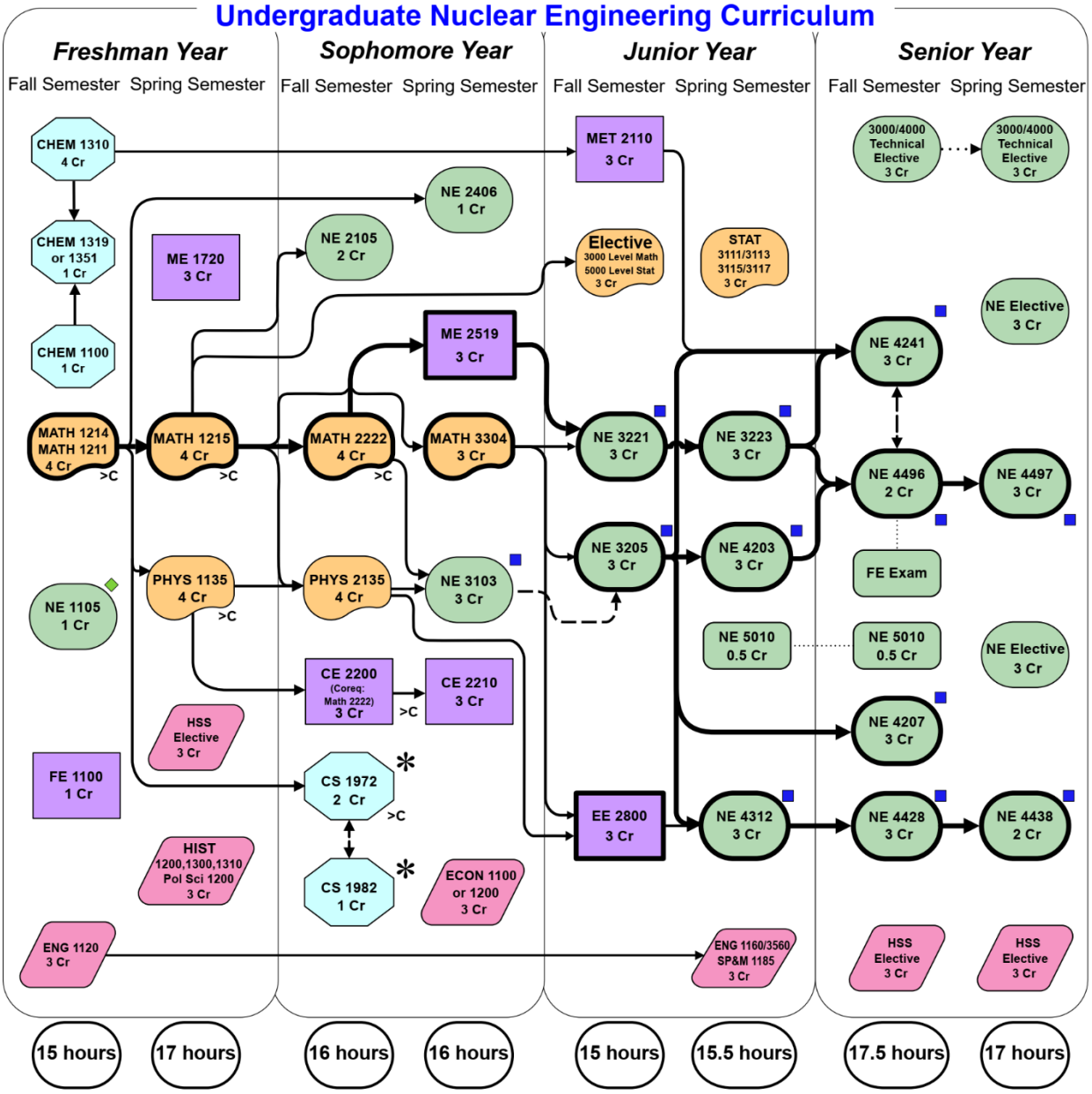
The plan of study shown on the next page should be used in creating your own plan to complete your degree. A few important comments on this process are:

- All necessary forms can be found on the Registrar's web site, http://registrar.mst.edu/forms/
- Note that most Nuclear Engineering courses are only **offered once per academic year**. For students on co-ops, some courses may be substituted for courses offered by other departments. This will require the submission of a substitution/waiver form.
- A full list of undergraduate courses currently offered by the NE program can be found in the nuclear engineering catalog, https://catalog.mst.edu/undergraduate/degreeprogramsandcourses/nuclearengineering/

GENERAL EDUCATION REQUIREMENTS

Missouri S&T's General Education requirements that will be satisfied by required courses in the Nuclear Engineering program include:

- Mathematical Science (3 credit hours) Choose from Math 1120, 1140, and Math 1210 or higher course number.
- Natural Sciences (7 credit hours including a minimum 1 credit hour of lab) Choose from at least two specific disciplines: Biology 1113 or higher, Chemistry 1301 or higher, Geology 1110 or higher, Physics 1111 or higher.



Plan of Study Flow Chart

- Communications (6 credit hours) English 1120, and choose one course from ENGL 1160, ENGL 3560, or Speech & Media 1185.

In planning your degree, you must also satisfy the following requirements:

- Humanities, Arts, and Social Sciences (15 credit hours) Choose courses from History, Art, Music, Theater, English and Technical Communication, Philosophy, Political Science, Psychology, Economics, Etymology, or Foreign Languages
    - 6 credits in the Humanities and Fine Arts, selected from two specific disciplines: History 1300*, 1310*, Art 1150, Music 1150, Theater 1150, and English 1211, 1212, 1221, 1222, and 1231 (or Non-prerequisite Literature).
    - 6 credits in the Behavioral and Social Sciences, selected from two specific disciplines: History 1100, 1200*, 2110, Philosophy 1105, 1115, Political Science 1200*, Psychology 1101, Econ 1100 or 1200, Foreign Languages 1101, 1102, and 1180.
    - 3 additional credits from any of these Humanities, Art, and Social Sciences disciplines

EXPERIENTIAL LEARNING REQUIREMENT

All students at Missouri S&T are required to participate in appropriate experiential learning activities. Experiential learning refers to learning stimulated by a variety of structured activities that differ significantly from the traditional lecture format. 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. To qualify:

1. The activity must be University sponsored or affiliated and the student must receive written approval of the activity from an academic advisor in the student's degree program. Approval of the initial activity does not automatically imply approval of the overall experience.
2. The academic advisor will ensure that the activity is of significant duration, intensity and rigor to demonstrate successful application of learned principles appropriate to the expectations of the degree program.
3. The focus must be on "learning by doing" in a creative and innovative activity that generally falls outside the realm of the traditional lecture classroom experience and contributes significantly to professional and personal development.
4. Finally, a significant experiential learning activity will include a *written summary reflection piece* that will document the experience from the student's perspective; this written reflection piece should be of a quality suitable for inclusion as an attachment to a co-curricular transcript or in an e-portfolio that might be submitted by the student to potential employers or to graduate school admissions committees.

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

- Co-ops or internships with national laboratories, nuclear utilities, vendors, nuclear medical or other relevant companies
- Undergraduate research (OURE, NSF Research Experience for Undergraduates, Honors Academy senior research project, etc.)
- Participation in ANS or other relevant design competition to completion
- Study abroad program
- S&T-sponsored service learning (EWB, Miner Challenge, etc.)
- Leadership positions with student organizations (ANS, NSDT, WiN). Leadership experience must be significant. This type of experience must be endorsed by the other leaders of the organization by signatures of the current officers on the assignment.
- Year-long leadership involvement experiences (Global Leaders Institute, Chancellor's Leadership Academy, Student Leadership Conference Chair, Intercollegiate Athletics Team)

Other types of activities may be considered acceptable with *prior approval*. Upon completing your experiential learning requirement, the Experiential Learning Form (http://academicsupport.mst.edu/media/administrative/academicsupport/documents/experientiallearning/EL%20Activity%20Form.pdf) must be completed and submitted.

In addition to the form, an appropriate reflective essay must be completed. The reflective essay should describe your activity, as well as the benefits you received from participating in the activity that you would not have received from classroom instruction.

Senior Assessment

All programs at Missouri S&T are required to have a senior assessment. The NE program requires that all students complete a senior assessment exam prepared by the department and administered through Canvas. When you are preparing to graduate, NERS will provide information on how to take the exam. The results of the assessment do not affect students' ability to graduate, but are reported in aggregate for use in assessing the effectiveness of the NE curriculum. All seniors are also required to complete a senior exit questionnaire as part of their assessment.

Minor in Nuclear Engineering

A nuclear engineering minor enhances the academic credentials of a student and broadens his/her employment choices. A minimum of 15 hours is required for a minor in nuclear engineering. Before the courses listed below can be taken, the student should have completed MATH 3304 (or equivalent) and PHYSICS 2305 (or NUC ENG 3103 or equivalent). Required courses are:

NUC ENG 3205	Fundamentals of Nuclear Engineering	3 Credit-Hours
NUC ENG 4312	Nuclear Radiation Measurements and Spectroscopy	3 Credit-Hours

The other 9 hours should be selected from nuclear engineering 3000 or higher level courses.

HONORS PROGRAMS

The Missouri S&T Honors Academy offers students the opportunity to be a part of a community of outstanding scholars who are seeking an enhanced educational experience. At Missouri S&T, Honors Academy students are recognized for their academic excellence and are provided with individualized attention and opportunities to establish leadership development skills, interact with faculty members, and participate in special projects including undergraduate research, service learning, and other beneficial experiences.

Incoming freshmen are eligible to apply if:

- ACT score is 29 or higher/SAT is 1440 or above
- Rank in the top ten percent of their high school class or have a minimum GPA of 3.5

Incoming transfer students and students currently enrolled at Missouri S&T are eligible to apply if they have the following:

- A minimum GPA of 3.5
- A minimum of 24 graded, college-level credits

Honors Academy (Sophomore-Senior Year)

Following their first year, Honors Academy students must maintain a minimum GPA of 3.5 to continue their participation in the program. Honors Academy students will enroll in and complete 15 credit hours of "Honors" course work to include 12 hours of "Honors" course work and three hours of Senior Project. The "Honors" course designation is based on extra work conducted in regular Missouri S&T courses wherein the instructor agrees to approve and oversee the effort. Course requirements include:

- One course must be outside of the major field of study.
- During the senior year, Honors Academy students will complete three hours of Senior Thesis/Project, write a thesis and present their findings to the Honors Committee.
- No more than three credit hours may be individual study courses.

Honors Distinctions

Honors Academy students who graduate with a 3.5 GPA or better and have at least 15 credit hours of "Honors" course credits and present their thesis findings will earn the distinction of "Honors Academy Fellow" at graduation. This distinction will be noted on their diploma, transcript, and commencement program. For more information, please contact the office of academic support at 573-341-7276.

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. Currently 18 students are licensed ROs or SROs at the Missouri S&T Reactor, and they support a wide range of operations in the facility.

This license does not 'travel', so students seeking employment as ROs at other reactors would have to re-license. However this program provides valuable learning, experience, and insight into the process. Students who are interested in the program should contact Ethan Taber (etaber@mst.edu)

DUAL ENROLLMENT

The purpose of dual-enrollment is to give S&T students an opportunity to earn graduate credit for courses taken (not required for an undergraduate degree) while still an undergraduate. In general, undergraduates are not permitted to enroll for 5000-level courses. However, an undergraduate may earn credit toward their bachelor's degree for courses normally taken by first-year graduate students (5000-level courses). Students are eligible to enroll when they have:

- Obtained senior status,
- A minimum GPA of 3.5 if two semesters remain, 3.0 if in their final semester.

Dually enrolled students are limited to sixteen total credit hours per semester, but petitions for additional credit hours will be considered by the Provost. Petition forms are available at http://registrar.mst.edu/media/administrative/registrar/documents/dualenrolled.pdf. If a dually enrolled student fails to meet minimum undergraduate scholastic standards, his or her resulting academic probationary status will be that of an undergraduate and will be evaluated without reference to the student's grades in his or her graduate course(s).

To apply for dual enrollment, complete the online application for graduate school admission and choose dual enrollment as your academic level on the application. Missouri S&T undergraduate students applying for graduate dual-enrollment need not pay the graduate school application fee or submit GRE or GMAT scores. These scores will be necessary if you wish to later apply as a full-time graduate student.

General application deadlines:

Fall Semester - July 15
Winter/Spring Semester - December 15
Summer Session - May 1

GRAD TRACK PATHWAY

Nuclear Engineering offers the Grad Track Pathway to exceptional undergraduate students for early provisional admission to the master's degree program. This accelerated program is designed for such students to earn coursework credits toward their master's degree while completing their bachelor's degree in a discipline as approved by the prospective graduate program. A Grad Track Pathway is defined by a set of graduate-level courses (no more than nine credit hours) that apply towards the bachelor's degree and then also towards their associated master's degree.

Graduate coursework taken for undergraduate credit will be considered advanced level, will be included in the student's undergraduate GPA, and will be assessed undergraduate tuition rates. Advanced level coursework includes any 5000- or 6000-level lecture courses approved for use in the pathway. Graduate coursework taken for undergraduate credit as part of the pathway applies to the associated master's degree when the student has completed the bachelor's degree, has been admitted to the associated master's degree program, and the Form 1 (Plan of Study) has been approved.

Program Requirements:

1. A student is eligible to apply to the pathway once the following criteria are met:
    - Must be one year from graduation of their bachelor's degree (excluding the semester they are currently enrolled).
    - Must have a 3.0 minimum cumulative GPA.
    - Must have a 3.5 minimum GPA in a group of designated courses specified by the department.
2. Eligible students must submit the "Admission and Course Approval" form to the graduate advisor, the department chair or designee, and then the dean of graduate studies. Individual departments may require additional documents such as unofficial copies of transcripts, statements of purpose, letters of recommendation, or standardized test scores. The signed "Admission and Course Approval" form ensures the pathway courses will satisfy degree requirements for the student's bachelor's degree program.
3. Students must maintain a cumulative GPA of at least 3.00 until they receive their bachelor's degree.
4. Students must receive grades of B or better in the graduate courses they enroll in as part of the pathway course sequence.
5. Students actively taking pathway courses must formally apply for admission to the master's program associated with the pathway. This requires submitting a formal application for admission so that the semester admit term for the master's degree immediately follows the semester that the bachelor's degree is awarded. In the admission application, the student will be able to indicate that they are currently enrolled as a Grad Track Pathway student.

6. If a student does not satisfy the pathway requirements above, they may still be admitted to the master's program, but will not be able to apply the courses from the bachelor's degree towards their master's program of study.
7. Grades earned in graduate-level courses while officially registered as an undergraduate student will count towards the student's cumulative undergraduate GPA, and cannot be factored into the cumulative graduate GPA.
8. Credits earned in graduate-level courses will be posted according to established registrar procedures to the undergraduate transcript and will apply towards the student's undergraduate degree hours as needed to obtain the undergraduate degree and thus ensure all stated degree requirements are met.
9. Once the bachelor's degree is awarded, the student is fully admitted to the associated master's program, and the Form 1 is approved, the courses from the pathway will be included on the student's graduate degree audit.

6. STUDENT ORGANIZATIONS

AMERICAN NUCLEAR SOCIETY

The American Nuclear Society (ANS) is a not-for-profit, international, scientific and educational organization. It was established by a group of individuals who recognized the need to unify the professional activities within the various fields of nuclear science and technology. December 11, 1954, marks the Society's historic beginning at the National Academy of Sciences in Washington, D.C. ANS has since developed 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 classroom 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. 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 organization was established in May 1999 with the 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. Local chapters are organized based on company, university/college, or geographic region. In addition, U.S. WIN is an affiliate of the Women in Nuclear Global organization (WiN Global). The WiN-Global organization is made up of thousands of members in more than 100 countries.

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 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. Business, marketing, logistics, communications and teamwork skills that design teams incorporate in their day-to-day operations mirror the global design process used in industry world-wide. Design team members network with industry professionals and students from competing schools alike, forming personal and professional relationships that can lead to rewarding careers.

S&T design team veterans "know how to think on their feet, don't mind getting their hands dirty, and are ready to contribute on their first day at work" say many firms who hire our team members, and why so many businesses aggressively recruit S&T students with design team experience.

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.

7. Advice From Previous Students

In order to make the most of your time in Nuclear Engineering, there are a few things that every student should do. Each year we ask the outgoing senior class what advice they would have liked to receive as an incoming Freshmen. Some of the common responses are:

- "Create a study group; GroupMe is a great resource. Start studying in groups as early as possible. Make friends with fellow students. You learn better as a group even if you do not think so."
- "Apply early and often – for internships and jobs. Actively pursue internships or co-ops, it makes it much easier to get a job later."
- "Take some extra coding and logic classes (PHIL 1110, PHIL 1115, CS courses)"
- "Be active in extracurricular activities – everyone takes classes, so doing the minimum won't set you apart."
- "Take MATLAB and MCNP."
- "Get to know the professors, they are not scary and are a great resource."
- "Get involved with ANS and WiN"
- "Make sure you understand the basics from Fundamentals of Nuclear Engineering. The information in this course will be used all throughout the rest of your nuclear engineering courses."
- "You get out what you put in. You have to apply yourself to really learn anything. Don't just skate along."
- "Getting to know the upperclassmen and graduate students is smart because the might be able to help to with classes or finding jobs."

APPENDIX A: LIST OF EMPLOYERS

UTILITIES			
Associated Electric Cooperative Inc.	www.aeci.org		Springfield, MO
Ameren	www.ameren.com	Callaway	Fulton, MO
Arizona Public Service Co.	www.aps.com	Palo Verde	Phoenix, AZ
Constellation Energy	www.constellation.com	Calvert Cliffs	Annapolis, MD
		Ginna	Rochester, NY
		Nine Mile Point	Oswego, NY
Detroit Edison Co.	www.dteenergy.com	Fermi	Toledo, OH
Dominion Generation	www.dom.com	Kewaunee	Green Bay, Wi
		Millstone	New London, CT
		North Anna	Richmond, VA
		Surry	Newport News, VA
Duke Energy Power Company, LLC	www.duke-energy.com	Catawba	Charlotte, NC;
		McGuire	Charlotte, NC;
		Oconee	Greenville, SC
Emerson Electric			Marshalltown, IA
Energy Northwest	www.energy-northwest.com	Columbia Generating Station	Pasco, WA
Entergy	www.entergy.com	ANO	Russellville, AR
		FitzPatrick	Oswego, NY
		Grand Gulf	Vicksburg, MS
		Indian Point	New York City, NY
		Palisades	South Haven, MI
		Pilgrim	Boston, MA
		River Bend	Baton Rouge, LA
		Vermont Yankee	Brattleboro, VT
		Waterford	New Orleans
Exelon	www.exeloncorp.com	Braidwood	Joliet, IL
		Bryon	Rockford, IL
		Clinton	Bloomington, IL
		Dresden	Joliet, IL
		La Salle	Ottawa, IL
		Limerick	Philadephia, PA
		Oyster Creek	Toms River, NJ
		Peach Bottom	Lancaster, PA
		Quad Cities	Moline, IL
		Texas Site (Green Field)	Victora County, TX
		Three Mile Island	Harrisburg, PA

FirstEnergy	www.firstenergycorp.com	Beaver Valley Davis-Besse Perry 1	McCandless, PA; Toledo, OH Cleveland, OH
Florida Power and Light	www.fpl.com	Duane Arnold Point Beach Saint Lucie Seabrook Turkey Point	Cedar Rapids, IA Manitowoc, WI Ft. Pierce, FL Portsmouth, NH Miami, FL
Indiana/Michigan Power Co.	www.cookinfo.com	D.C. Cook	Benton Harbor, MI
Luminant/TXU	www.luminant.com	Comanche Peak	Fort Worth, TX
Nebraska Public Power District	www.nppd.com	Cooper	Brownsville, NE
Nuclear Management Co.	www.nuclearmanagementpartners.com	Monticello Prairie Island	Minneapolis, MN Minneapolis, MN
Omaha Public Power District	www.oppd.com	Fort Calhoun	Omaha, NE
Pacific Gas and Electric	www.pge.com	Diablo Canyon	San Luis Obispo, CA
PPL Susquehanna, LLC	www.pplweb.com	Susquehanna	Harrisburg, PA
Progress Energy	www.progress-energy.com	Brunswick Crystal River Levy County (Green Field) Robinson Harris	Wilmington, NC Tampa, FL Levy County, FL Florence, SC Raleigh, NC
PSE&G	www.pseg.com	Hope Creek Salem	Wilmington, DE Wilmington, DE
South Carolina Electric & Gas Co.	www.sceg.com	Summer	Columbia, SC
Southern California Edison Co.	www.sce.com	San Onofre	Long Beach, CA
Southern Power	www.southerncompany.com	Farley Hatch Vogtle	Dothan, AL Vidalia, GA Augusta, GA
STP Nuclear Operating Co.	www.stpnoc.com	South Texas Project	Bay City, TX
TVA	www.tva.gov	Browns Ferry Sequoyah Watts Barr Bellefonte Unnamed	Huntsville, AL Chattanooga, TN Spring City, TN Hollywood, AL Oak Ridge, TN
Wolf Creek	www.wcnoc.com	Wolf Creek	South East Kansas
Xcel Energy	www.xcelenergy.com		

ARCHITECTURAL/ENGINEERING/CONSTRUCTION		
Shaw Group	www.shawgrp.com	
Black & Veatch	www.bv.com	Kansas City, MO
Burns & McDonnel	www.burnsmcd.com	Kansas City, MO
Sargent & Lundy	www.sargentlundy.com	
RCS Corporation	www.rcscorporation.com	
Enercon	www.enercon.com	
Areva	www.areva.com	World
Burns & Roe	www.roe.com	New Jersey
URS	www.urscorp.com	San Francisco, CA
K&M Engineering & Consulting Co.	http://kmec.com	Washington, DC
Fluor	www.fluor.com	
Enercon Services, Inc	www.enercon.com	Overland Park, KS
Kairos Power	http://www.kairospower.com	Oakland, CA
MILITARY SUPPORT/DESIGN		
Bechtel	www.bechtel.com	Idaho Falls, ID Kesselring, NY
Bechtel Marine Propulsion	-	Albany, NY Niskayuna, NY Idaho Falls, ID
Knolls Atomic Power Laboratory	www.knollslab.com	
Boeing	www.boeing.com	
Booz, Allen & Hamilton	www.boozallen.com	
DRS Power & Control Technologies	www.drs.com	
Raytheon Company	www.raytheon.com	
NUCLEAR PARTS/SUPPORT		
Emerson	www2.emersonprocess.com	
Ruskin	www.ruskin.com	
Faukse and Associates	www.fauske.com	
NAI	www.numerical.com	
Alion	www.alionscience.com	
Scientech	www.scientech.cwfc.com	
ABS Consulting	www.absconsulting.com	Irvine, CA
Holtec	www.holtecinternational.com	New Jersey, Florida
Flowserve	www.flowserve.com	
Alstom	www.alstom.com	France
Science Applications International Corporation	www.saic.com	McLean, VA

Electrical Power Research Institute	http://my.epri.com	Palo Alto, CA
Flodyne-Hydradyne, Inc.	www.cmafh.com	
FMC Corporation	www.fmc.com	
General Electric	www.ge.com	
Halliburton Services	www.halliburton.com	
Honeywell's Technology Center	www.honeywell.com	
Jason Associates Corporation	http://jason.com/	
PECO Engineering	http://pecovalves.com	
RSO Incorporated	www.rsoinc.com	Baltimore, MD
Tate Engineer Systems, Inc.	www.tate.com	
TransWare Enterprises, Inc.	http://transware.net/	
CSA	http://csai.com/	Idaho Falls, ID
Worley Parsons Group Inc	www.Worleyparsons.com	All over the World
Structural Integrity Associates Inc	www.structint.com	All over the World
NUCLEAR WEBSITES		
NukeWorker	www.NukeWorker.com	
Price Waterhouse Coopers	www.pwc.com	
NUCLEAR FUEL		
USEC	www.usec.com	Bethesda, MD
Global Nuclear Fuel - Americas, LLC		Wilmignton, NC
NAC International	www.nacintl.com	Atlanta, GA
Lightbridge	http://ltbridge.com/	McLean, VA
Nuclear Fuel Services	www.nuclearfuelservices.com	Erwin, TN
NATIONAL LABORATORIES		
Argonne National Laboratory	www.dep.anl.gov	Chicago, IL
Bettis Atomic Power Laboratory		Pittsburgh, PA
Brookhaven National Laboratory	www.bnl.gov	Upton, NY
Idaho National Laboratory	https://inlportal.inl.gov	Idaho Falls, ID
Lawrence-Livermore National Laboratory	https://scholars.llnl.gov	San Francisco, CA
Los Alamos National Laboratory	www.lanl.gov	Los Alamos, NM
Oak Ridge National Laboratory	www.orau.org/ornl	Knoxville, TN
Pacific Northwest National Laboratory	http://science-ed.pnl.gov	Richland, WA
Sandia National Laboratories	http://sandia.gov/	Albuquerque, NM

Battelle Memorial Institute	www.battelle.org	Columbus, OH
Navy Nuclear Laboratory	https://navalnuclearlab.energy.gov/	Charleston, SC
UNIVERSITIES (GRAD SCHOOL)		
UMC Environmental Health & Safety	http://ehs.umc.edu/	Jackson, MS
Missouri S&T	www.mst.edu	Rolla, MO
University of Akron	www.uakron.edu	Akron, OH
University of California	www.universityofcalifornia.edu	Oakland, CA
University of California - Berkeley	www.berkeley.edu	Berkeley, CA
University of Illinois	http://illinois.edu	Urbana-Champaign, IL
University of Michigan - Nuclear Engineering Department	www.umich.edu	Ann Arbor, MI
University of Texas - SW Medical Center	www.utsouthwestern.edu	Dallas, TX
Washington University	www.wustl.edu	St. Louis, MO
Rensselaer Polytechnic Institute	www.rpi.edu	Troy, NY
Texas A&M	www.tamu.edu	College Station, TX
Massachusetts Institute of Technology		Cambridge, MA
Vanderbilt University		
Louisiana State University	www.lsu.edu	Baton Rouge, LA
Purdue University	www.purdue.edu	West Lafayette, IN
NNSA Fellow	http://ngp.pnnl.gov/	Richland, WA
GOVERNMENT/MILITARY		
Defense Nuclear Facilities	www.dnfsb.gov	
NRC	www.nrc.gov	
U.S. Air Force	www.airforce.com	
U.S. Army	www.goarmy.com	
U.S. CIA	www.cia.gov	
U.S. Coast Guard	www.gocoastguard.com	
U.S. Navy	www.navy.mil	
U.S. Navy - NUPOC	www.navy.com/nupoc	
U.S. Dept. of Energy	www.energy.gov	
U.S. Dept. of Transportation	www.dot.gov	
U.S. EPA	www.epa.gov	
NASA	www.nasa.gov	
CSRA	www.csra.com	

NUCLEAR MEDICINE		
NuView Life Sciences		Denton, Texas
NorthStar Medical Radioisotopes		Beloit, WI
Curium	https://curiumpharma.com	St. Louis, MO
Phoenix Nuclear Labs	http:// phoenixnuclearlabs.com	Monona, WI
OTHER		
Lockheed Martin		Plamdale, CA
Ford Motor Company		Dearborn, MI
Honeywell		Kansas City, MO
Newport News Shipbuilding		Newport News, VA
Ruskin		Grandview, MO
PPG Industries	http://corporate.ppg.com	Mt. Vernon, IL
Phase Change Energy Solutions	https://www.phasechange.com/	Asheboro, NC
Superior Pipeline	www.superiorpipeline.com	Tulso, OK
Epic Systems Corp	www.epic.com	Verona, WI
King Abulaziz City for Science and Technology	www.kacst.edu.sa/eng/Pages/default.aspx	Riyadh, Saudi Arabia
Ankara University	www.ankara.edu.tr	Ankara, Turkey

APPENDIX B: NUCLEAR ENGINEERING FOCUS AREAS

Nuclear Power Engineering

Why study Nuclear Power?

- Start a career in nuclear energy or at a nuclear energy/small modular reactor startup
- Become a nuclear fuel designer
- Design improvements for nuclear power plants
- Perform cutting-edge research related to developing new nuclear reactor technologies
- Become a licensed nuclear reactor operator

In addition to the required Nuclear Engineering coursework, students should select as electives:

- NUC ENG 5251: Reactor Kinetics
- NUC ENG 5253: Monte Carlo Approach to Reactor Analysis
- NUC ENG 5257: Introduction to Nuclear Thermal Hydraulics
- NUC ENG 5259: Licensing of Nuclear Power Plants

Reactor Safety

Why study Reactor Safety?

- Start a career in national laboratories or at nuclear energy startups
- Develop safety improvements in nuclear power plants
- Understand and provide science- and technology-based contributions to improve the regulations surrounding nuclear energy

In addition to the required Nuclear Engineering coursework, students should select as electives:

- NUC ENG 5257: Introduction to Nuclear Thermal Hydraulics
- NUC ENG 5259: Licensing of Nuclear Power Plants
- NUC ENG 5281: Introduction to Probabilistic Risk Assessment
- NUC ENG 6257: Advanced Nuclear Thermal Hydraulics

Taking a 6000-level course as an undergraduate student requires permission from the student's advisor and the course instructor.

Nuclear Security

Why study Nuclear Security, Safeguard and Policy?

- Contribute to keeping our nation and our nuclear material safe
- Advocate for science-based policy surrounding nuclear energy and nuclear materials
- Promote peaceful uses for nuclear technology
- Contribute to technologies and policies that will reduce or eliminate the threat of nuclear conflict

In addition to the required Nuclear Engineering coursework, students should select as electives:

- NUC ENG 5367: Radioactive Waste Management
- NUC ENG 5507: Nuclear Policy
- NUC ENG 5509: Nuclear Nonproliferation
- NUC ENG 5577: Nuclear Forensics

And, as General Education electives:

- POL SCI 3762: American Foreign Policy Since 1945, or
- POL SCI 4500: Geopolitics and International Security

Health Physics

Why study Health Physics?

- Understand radiation hazards and how to prevent or control them
- Wide opportunity for jobs with hospitals, regulators (government), schools, big industries where radiation is used or encountered in regular course of business
- As a medical health physicist, help make hospitals safe for patients and medical staff
- Manage environmental procedures for companies using radiation-based technologies in medical isotope production, well logging, weld inspection, x-ray imaging, manufacturing and quality control, and many other applications

In addition to the required Nuclear Engineering coursework, students should select as electives:

- NUC ENG 5281: Introduction to Probabilistic Risk Assessment
- NUC ENG 5347: Radiological Engineering
- NUC ENG 5363: Applied Health Physics
- NUC ENG 5367: Radioactive Waste Management

Pre-Med

Why study Pre-medicine?

- About one-third of major procedures in hospitals have nuclear engineering applications
- Study a flexible degree to prepare you for medical school or an engineering career
- Pursue a graduate program in Medical Physics, which allows you to work in healthcare facilities, perform research to improve cancer treatment, or design treatment plans for patients

A detailed plan of study for this program is provided below. This plan of study fulfills all of the requirements for a Nuclear Engineering degree as well as the essential requirements of a premed program. However students should note that this plan of study requires the completion of 143 credit-hours rather than the standard 129. Also, this plan of study requires a number of substitution/waiver forms, a much higher course load each semester, and it is expected that students will need to include at least one summer semester in their plan of study. Students considering this degree path should work closely with their academic advisor(s) to ensure they are prepared for these requirements.

Freshman Year			
First Semester	***Credits***	***Second Semester***	***Credits***
ENGLISH 1120	3	HISTORY 1200, or 1300, or 1310, or POL SCI 1200	3
FR ENG 1100	1	MATH 1215	4
MATH 1214	4	MECH ENG 1720	3
NUC ENG 1105	1	PHYSICS 1135	4
CHEM 1100	1	ECON 1100 or 1200	3
CHEM 1310	4		
CHEM 1319	1		
	15		**17**
Sophomore Year			
First Semester	***Credits***	***Second Semester***	***Credits***
CIV ENG 2200	3	CIV ENG 2210	3
COMP SCI 1972, or 1970, or 1971	2	PREMED 1211 or BIO SCI 1201	3
COMP SCI 1982, or 1980, or 1981	1	MATH 3304	3
MATH 2222	4	MECH ENG 2519	3
CHEM 1320	3	NUC ENG 2406	1
PHYSICS 2135	4	NUC ENG 2105	2
		NUC ENG 3103, or PHYSICS 2305, or PHYSICS 2311	3
	17		**18**
Junior Year			
First Semester	***Credits***	***Second Semester***	***Credits***
ELEC ENG 2800	3	BIO SCI 1113 or BIO SCI 1213	3
MET ENG 2110	3	NUC ENG 4312 or 5312	3
NUC ENG 3205	3	NUC ENG 3223	3
NUC ENG 3221	3	NUC ENG 4203 or 5203	3
COMP SCI 3200 (OR 3000 Level MATH, 5000 Level STAT)	3	STAT 3111 or 5425	3
CHEM 2210	4	CHEM 2220	4
	19		**19**
Summer Semester			
First Semester	***Credits***		
ENGLISH 1160, or 3560, or SPM S 1185	3		

Senior Year			
First Semester	***Credits***	***Second Semester***	***Credits***
NUC ENG 4207 or 5207	3	NUC ENG 4438 or 5438	2
NUC ENG 4241 or 5241	3	NUC ENG 4497	3
NUC ENG 4428 or 5428	3	BIO SCI 2263	3
NUC ENG 4496	2	BIO SCI 3343	3
BIO SCI 3333	3	BIO SCI 3349	1
BIO SCI 3339	1	CHEM 4610	3
BIO SCI 2223	3	CHEM 4619	1
		PREMED 3010 or BIO SCI 4010	1
	18		**17**
Total Credits: 143			