NUCLEAR ENGINEERING AND ENGINEERING PHYSICS, PH.D.

A broad program of instruction and research is offered in the principles of the interaction of radiation with matter and their applications, and in several areas of engineering physics. The program has strong engineering and applied science components. It emphasizes several areas of activity, including the research, design, development, and deployment of fission reactors; fusion engineering; plasma physics; radiation damage to materials; applied superconductivity and cryogenics; and large-scale computing in engineering science.

The master’s degree may be pursued as a terminal degree in the fission area and in various engineering physics areas, but it is not generally recommended as a final degree in fusion research; students interested in fusion should plan to pursue the Ph.D. degree. About 40 percent of the current graduate students hold undergraduate degrees in nuclear engineering, about 40 percent in physics, and about 20 percent in other disciplines such as mechanical engineering, electrical engineering, mathematics, and materials science.

The department is considered to have one of the top five nuclear engineering programs in the nation over the last 40 years. It incorporates several research organizations including the Wisconsin Institute of Nuclear Systems, the Pegasus Toroidal Experiment Program, the Fusion Technology Institute, and the Center for Plasma Theory and Computation.

Research may be performed in areas including next generation fission reactor engineering; fluid and heat transfer modeling for transient analysis; reactor monitoring and diagnostics; fuel cycle analysis; magnetic and inertial confinement fusion reactor engineering, including the physics of burning plasmas, plasma-wall interactions, neutron transport, tritium breeding, radiation damage, and liquid-metal heat transfer; experimental and theoretical studies of plasmas including radio frequency heating, magnetic confinement, plasma instabilities, and plasma diagnostics; superconducting magnets and cryogenics; and theoretical and experimental studies of the damage to materials in fission and fusion reactors.

The department places considerable emphasis on establishing research teams or group research, as well as traditional research activity by individual faculty members and their students. The groups frequently involve faculty, scientific staff, and graduate students from several departments, adding a strong interdisciplinary flavor to the research.

Students sometimes perform thesis work at national laboratories such as Argonne National Laboratory, Idaho National Laboratory, Princeton Plasma Physics Laboratory, and Los Alamos National Laboratory.

ADMISSIONS

Please consult the table below for key information about this degree program’s admissions requirements. The program may have more detailed admissions requirements, which can be found below the table or on the program’s website. Graduate admissions is a two-step process between academic programs and the Graduate School. Applicants must meet the minimum requirements (https://grad.wisc.edu/apply/requirements) of the Graduate School as well as the program(s).

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall Deadline</td>
<td>December 15</td>
</tr>
<tr>
<td>Spring Deadline</td>
<td>October 1</td>
</tr>
<tr>
<td>Summer Deadline</td>
<td>December 15</td>
</tr>
<tr>
<td>GRE (Graduate Record Examinations)</td>
<td>Required.*</td>
</tr>
<tr>
<td>English Proficiency Test</td>
<td>Every applicant whose native language is not English or whose undergraduate instruction was not in English must provide an English proficiency test score and meet the Graduate School minimum requirements (<a href="https://grad.wisc.edu/apply/requirements/#english-proficiency">https://grad.wisc.edu/apply/requirements/#english-proficiency</a>).</td>
</tr>
<tr>
<td>Other Test(s) (e.g., GMAT, MCAT)</td>
<td>n/a</td>
</tr>
<tr>
<td>Letters of Recommendation Required</td>
<td>3</td>
</tr>
</tbody>
</table>

* Except for current UW-Madison NE/EP/EMA undergraduate students.

The Graduate School sets minimum requirements for admissions. (https://grad.wisc.edu/admissions/requirements) Academic program admission requirements are often more rigorous than those set by the Graduate School. Please check the program website (https://www.engr.wisc.edu/department/engineering-physics/academics/ms-nuclear-engineering) for details and admissions deadlines.

FUNDING

GRADUATE SCHOOL RESOURCES

Resources to help you afford graduate study might include assistantships, fellowships, traineeships, and financial aid. Further funding information (https://grad.wisc.edu/funding) is available from the Graduate School. Be sure to check with your program for individual policies and processes related to funding.

PROGRAM RESOURCES

Offers of financial support from the Department, College, and University are in the form of research assistantships (RAs), teaching assistantships (TAs), project assistantships (PAs), and partial or full fellowships. Prospective PhD students that receive such offers will have a minimum five-year guarantee of support. The funding for RAs comes from faculty research grants. Each professor decides on his or her own RA offers, and a portion of the top domestic applicants is invited to visit Madison in order to meet faculty members and tour the department facilities. International applicants must secure an RA, TA, PA, fellowship, or independent funding before admission is final. Funded students are expected to maintain full-time enrollment. See the program website (https://www.engr.wisc.edu/department/engineering-physics/academics/ms-nuclear-engineering) for additional information.
MINIMUM GRADUATE SCHOOL REQUIREMENTS

Review the Graduate School minimum academic progress and degree requirements (http://guide.wisc.edu/graduate/policiesandrequirementstext), in addition to the program requirements listed below.

MAJOR REQUIREMENTS

MODE OF INSTRUCTION

<table>
<thead>
<tr>
<th>Face to Face</th>
<th>Evening/Weekend</th>
<th>Online</th>
<th>Hybrid</th>
<th>Accelerated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Mode of Instruction Definitions

**Evening/Weekend:** These programs are offered in an evening and/or weekend format to accommodate working schedules. Enjoy the advantages of on-campus courses and personal connections, while keeping your day job. For more information about the meeting schedule of a specific program, contact the program.

**Online:** These programs are offered primarily online. Many available online programs can be completed almost entirely online with all online programs offering at least 50 percent or more of the program work online. Some online programs have an on-campus component that is often designed to accommodate working schedules. Take advantage of the convenience of online learning while participating in a rich, interactive learning environment. For more information about the online nature of a specific program, contact the program.

**Hybrid:** These programs have innovative curricula that combine on-campus and online formats. Most hybrid programs are completed on-campus with a partial or completely online semester. For more information about the hybrid schedule of a specific program, contact the program.

**Accelerated:** These on-campus programs are offered in an accelerated format that allows you to complete your program in a condensed time-frame. Enjoy the advantages of on-campus courses with minimal disruption to your career. For more information about the accelerated nature of a specific program, contact the program.

CURRICULAR REQUIREMENTS

**Requirements Detail**

- **Minimum Credit Requirement:** 51 credits approved by the student’s faculty advisor
- **Minimum Residence Credit Requirement:** 32 credits
- **Minimum Graduate Coursework Requirement:** 26 of the required 51 credits must be in graduate-level coursework from nuclear engineering, math, physics, chemistry, computer science, or any other engineering department except E P D; courses with the Graduate Level Coursework attribute are identified and searchable in the university’s Course Guide (http://my.wisc.edu/CourseGuideRedirect/BrowseByTitle).
- **Overall Graduate GPA Requirement:** 3.00 GPA required.

**Other Grade Requirements**

Courses in which grades of BC, C, or below are received cannot be counted toward the degree except as follows:

1. Credits of C will be allowed provided they are balanced by twice as many credits of A or by four times as many credits of AB
2. Credits of BC will be allowed provided they are balanced by twice as many credits of AB or by an equal number of credits of A

**Assessments and Examinations**

- **Ph.D. qualifying examination is required of all students.**
- **Final oral examination is required at the end of the thesis work.**

**Language Requirements**

- **No language requirements.**

REQUIRED COURSES

Students must fulfill the coursework requirements for the nuclear engineering and engineering physics M.S. (http://guide.wisc.edu/graduate/engineering-physics/nuclear-engineering-engineering-physics-mgs) degree whether receiving the M.S. degree or going directly to the Ph.D. They must complete an additional 9 credits of technical coursework at the graduate level, beyond the coursework requirement for the MS. Candidates must take three 700-level courses; must satisfy the Ph.D. technical minor requirement; and must satisfy the Ph.D. non-technical minor requirement.

The candidate is also required to complete, as a graduate student, one course at the 400 level or above in each of the following Areas: fission reactors; plasma physics and fusion; materials; engineering mathematics and computation (see Area Coursework Examples below).

**M.S. Coursework Requirements**

The following courses, or courses with similar material content, must be taken prior to or during the course of study: N E 427 Nuclear Instrumentation Laboratory; N E 428 Nuclear Reactor Laboratory or N E 526 Laboratory Course in Plasmas; N E 408 Ionizing Radiation or N E/ MED PHYS. 569 Health Physics and Biological Effects.

- **Thesis track:** maximum of 12 credits for thesis; at least 8 credits of N E courses 400 level or above; remaining credits (also 400 level or above) must be in appropriate technical areas; at least 9 credits must be 500 level and above; up to 3 credits can be seminar credits.
- **Non-Thesis track:** at least 15 credits of N E courses at the 400 level or above; remaining 15 credits (also 400 level or above) must be in appropriate technical areas; at least 12 credits must be at the 500 level or above; up to 3 credits can be seminar credits.

For both the thesis and non-thesis options, only one course (maximum of 3 credits) of independent study (N E 699 Advanced Independent Study, N E 999 Advanced Independent Study) is allowed.

1 These tracks are internal to the program and represent different pathways a student can follow to earn this degree. Track names do not appear in the Graduate School admissions application, and they will not appear on the transcript.
Appropriate technical areas are: Engineering departments (except Engineering and Professional Development), Physics, Math, Statistics, Computer Science, Medical Physics, and Chemistry. Other courses may be deemed appropriate by a student's faculty advisor.

**Area Coursework Examples**

These courses are examples that would meet the requirement and are not meant to be a restricted list of possible courses. The candidate is required to complete one course in each of the following areas:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fission Reactors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N E 405</td>
<td>Nuclear Reactor Theory</td>
<td>3</td>
</tr>
<tr>
<td>N E 408</td>
<td>Ionizing Radiation</td>
<td>3</td>
</tr>
<tr>
<td>N E 411</td>
<td>Nuclear Reactor Engineering</td>
<td>3</td>
</tr>
<tr>
<td>N/E/MED PHYS 506</td>
<td>Monte Carlo Radiation Transport</td>
<td>3</td>
</tr>
<tr>
<td>N E/M E 520</td>
<td>Two-Phase Flow and Heat Transfer</td>
<td>3</td>
</tr>
<tr>
<td>N E 550</td>
<td>Advanced Nuclear Power Engineering</td>
<td>3</td>
</tr>
<tr>
<td>N E 555</td>
<td>Nuclear Reactor Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>N E/M E 565</td>
<td>Power Plant Technology</td>
<td>3</td>
</tr>
<tr>
<td>N E/I SY E 574</td>
<td>Methods for Probabilistic Risk</td>
<td>3</td>
</tr>
</tbody>
</table>

**Plasma Physics & Fusion**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>N E/E C E/PHYSICS 525</td>
<td>Introduction to Plasmas</td>
<td>3</td>
</tr>
<tr>
<td>N E/E C E/PHYSICS 527</td>
<td>Plasma Confinement and Heating</td>
<td>3</td>
</tr>
<tr>
<td>N E/E C E 528</td>
<td>Plasma Processing and Technology</td>
<td>3</td>
</tr>
<tr>
<td>N E 536</td>
<td>Feasibility St of Power from Controlled Thermonuclear Fusion</td>
<td>3</td>
</tr>
</tbody>
</table>

**Materials**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>N E/M S &amp; E 423</td>
<td>Nuclear Engineering Materials</td>
<td>3</td>
</tr>
<tr>
<td>N E 541</td>
<td>Radiation Damage in Metals</td>
<td>3</td>
</tr>
<tr>
<td>PHYSICS 551</td>
<td>Solid State Physics</td>
<td>3</td>
</tr>
</tbody>
</table>

**Engineering Mathematics & Computation**

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>E P/E M A 547</td>
<td>Engineering Analysis I</td>
<td>3</td>
</tr>
<tr>
<td>E P/E M A 548</td>
<td>Engineering Analysis II</td>
<td>3</td>
</tr>
<tr>
<td>COMP SCI/ MATH 513</td>
<td>Numerical Linear Algebra</td>
<td>3</td>
</tr>
<tr>
<td>COMP SCI/ MATH 514</td>
<td>Numerical Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MATH 703</td>
<td>Methods of Applied Mathematics 1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Non-Technical Minor Requirements**

Ph.D. candidates must complete one of the following four study options prior to receiving dissertation status. As this is a formal requirement, the student should select a Non-Technical Minor early in the program, and must complete it to achieve dissertation status (see below). The Non-Technical Minor must be planned with the help of the candidate's advisor and must be approved by the Department Non-Technical Minor Advisor except for Study Option IV which must be approved by the Department faculty. A Non-Technical Minor Approval Form is available from the Graduate Student Services Office, 3182 Mechanical Engineering, and must be filed prior to submission of the doctoral plan form. Courses below the 400 level may be used as a part of the Non-Technical Minor.

### Study Option I: Technology-Society Interaction Coursework

This option is intended to increase the student's awareness of the possible effects of technology on society and of the professional responsibilities of engineers and scientists in understanding such side effects. These effects could, for example, involve the influence of engineering on advancement of human welfare, on the distribution of wealth in society, or on environmental and ecological systems.

Suggested courses for fulfilling Option I include:

<table>
<thead>
<tr>
<th>Code</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIV ENGR 320</td>
<td>Environmental Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CIV ENGR 423</td>
<td>Air Pollution Effects, Measurement and Control</td>
<td>3</td>
</tr>
<tr>
<td>ECON/A A E 474</td>
<td>Economic Problems of Developing Areas</td>
<td>3</td>
</tr>
<tr>
<td>GEOG/URB R PL 305</td>
<td>Introduction to the City</td>
<td>3-4</td>
</tr>
<tr>
<td>GEOG/URB R PL 505</td>
<td>Urban Spatial Patterns and Theories</td>
<td>3</td>
</tr>
<tr>
<td>GEOSCI/ENVIR ST 410</td>
<td>Minerals as a Public Problem</td>
<td>3</td>
</tr>
<tr>
<td>HIST SCI/MED HIST/RELIG ST 331</td>
<td>Science, Medicine and Religion</td>
<td>3-4</td>
</tr>
</tbody>
</table>

### Study Option II: Humanistic Society Studies Coursework

The basic objectives of this option are to help prepare the student to bridge the gap between C.P. Snow's "Two Cultures." Snow's 1959 lecture thesis was that the breakdown of communication between the "two cultures" of modern society - the sciences and the humanities - was a major hindrance to solving the world's problems. Study might be designed to give a greater appreciation of the arts such as the classics, music, or painting, or it might be designed, for example, as preparation for translating technical information to the non-technical public.

Suggested areas of study to fulfill Option II include Anthropology, Area Studies, Art, Art History, Classics, Comparative Literature, Contemporary Trends, English (literature), Foreign Languages (literature), Social Work, Sociology, and Speech. Under either Option I or II, the student must take 6 credits of coursework. The courses must be approved by the student's advisor and the non-technical minor advisor, and the 6 credits should be concentrated in one topical area. Grades in these courses need not meet the Departmental Grade Policy. However, note that all grades in 300 level or above courses (including grades for Non-Technical Minor courses) are calculated in the Graduate School minimum 3.0 graduation requirement.

### Study Option III: Foreign Culture Coursework

This option is intended for the student who desires to live and work in a foreign nation or work with people of a foreign culture. Examples include studies of the history of a foreign nation, of the political stability of a region of the world, of the culture of a particular group within a nation, or of the spoken language of a foreign nation. For Option III the student must take six credits of courses under all of the same conditions and requirements as for Option I and II unless choosing language study. For the latter case, the student must attain a grade of C or better in all courses. If the student has previous knowledge of a language, it is required that either courses beyond the introductory level will be elected or that another language will be elected.

### Study Option IV: Technology-Society Experience

There are many possible technology-society interactions that might be more educational and meaningful for the student as an actual experience than coursework. For example, the student might run for and be elected to a position of alderperson in the city government. Consequently, this option
allows the student to pursue a particular aspect of the interaction using his own time and resources.

Study Option IV activity must be planned with the student's advisor and be approved by the faculty. The effort required should be equivalent to 6 credits of coursework. Upon completion of this program, the student will prepare a written or oral report.

Note: Foreign students from countries in which English is not the native tongue have inherently fulfilled these non-technical study goals and are exempt from these formal requirements.

Policies

Graduate School Policies
The Graduate School's Academic Policies and Procedures (https://grad.wisc.edu/acadpolicy) provide essential information regarding general university policies. Program authority to set degree policies beyond the minimum required by the Graduate School lies with the department faculty. Policies set by the academic degree program can be found below.

Major-Specific Policies
Graduate Program Handbook
The Graduate Program Handbook (https://www.engr.wisc.edu/department/engineering-physics/academics/ms-nuclear-engineering) is the repository for all of the program's policies and requirements.

Prior Coursework
Graduate Work from Other Institutions
With program approval, students are allowed to count no more than 6 credits of graduate coursework from other institutions toward the minimum graduate degree credit requirement and the minimum graduate coursework (50%) requirement. Coursework earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

Graduate Coursework from Previous M.S.
Students may apply up to 15 credits of prior coursework that led to an MS degree in a relevant field, provided:

- The student's faculty advisor agrees that the prior coursework proposed by the student satisfies the NEEP Ph.D. program requirements in terms of subject area and rigor.
- A member of the EP Graduate Studies Committee who is familiar with the NEEP Ph.D. program confirms the advisor's recommendation.

A student applying the 15 graduate credits from a previous M.S. is not eligible for applying previous undergraduate credits or other graduate credits (described above) toward the Ph.D. Coursework earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

UW–Madison Undergraduate
With faculty approval, students who have received their undergraduate degree from UW–Madison may apply up to 7 credits numbered 400 or above toward the minimum graduate degree credit requirement. This work would not be allowed to count toward the 50% graduate coursework minimum unless taken at the 700 level or above. No credits can be counted toward the minimum graduate residence credit requirement. Coursework earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

With faculty approval, students who have received an ABET-accredited undergraduate degree (not including UW–Madison) may be eligible to apply up to 7 credits of their undergraduate coursework toward the Minimum Graduate Degree Credit Requirement. No credits can be counted toward the Minimum Graduate Residence Credit Requirement, nor the Minimum Graduate Coursework (50%) Requirement.

Coursework earned five or more years prior to admission to a master's degree is not allowed to satisfy requirements.

UW–Madison University Special
With program approval, students are allowed to count up to 15 credits of coursework numbered 400 or above taken as a UW–Madison special student toward the minimum graduate residence credit requirement, and the minimum graduate degree credit requirement. UW–Madison coursework taken as a University Special student would not be allowed to count toward the 50% graduate coursework minimum unless taken at the 700 level or above. Coursework earned ten years or more prior to admission to a doctoral degree is not allowed to satisfy requirements.

Probation
A semester GPA below 3.0 will result in the student being placed on academic probation. If a semester GPA of 3.0 is not attained during the subsequent semester of full time enrollment (or 12 credits of enrollment if enrolled part-time) the student may be dismissed from the program or allowed to continue for one additional semester based on advisor appeal to the Graduate School.

Advisor / Committee
Each student is required to meet with his or her advisor prior to registration every semester.

Credits Per Term Allowed
15 credits

Time Constraints
The Ph.D. qualifying examination should be first taken no later than completion of the M.S. requirements, or the beginning of the fifth semester of graduate study, whichever comes first. Students entering the program with a master's degree in E M A, E P or N E from another institution, and taking the qualifying exam in that same major, must take the exam by the beginning of their third semester.

Students must submit the doctoral plan of study one month before the end of the semester following the one in which the qualifying exam is passed.

Candidates are expected to pass the Ph.D. preliminary examination no later than the end of the third year of graduate study, or by the end of the second regular semester following the one in which the Ph.D. qualifying examination was passed, whichever is later. A candidate who fails to take the preliminary examination within
four years of passing the qualifying examination must retake the qualifying examination.

An oral examination on the findings of the Ph.D. research is required at the end of the thesis work. The candidate must apply for a warrant from the Graduate School through the student services office at least three weeks before the exam. The final oral examination must be taken within five years of passing the preliminary examination.

PROFESSIONAL DEVELOPMENT

GRADUATE SCHOOL RESOURCES

Take advantage of the Graduate School's professional development resources (https://grad.wisc.edu/pd) to build skills, thrive academically, and launch your career.

LEARNING OUTCOMES

1. Demonstrate an extraordinary, deep understanding of mathematical, scientific, and engineering principles in the field
2. Demonstrate an ability to formulate, analyze, and independently solve advanced engineering problems
3. Apply the relevant scientific and technological advancements, techniques, and engineering tools to address these problems
4. Recognize and apply principles of ethical and professional conduct
5. Demonstrate an ability to synthesize knowledge from a subset of the biological, physical, and/or social sciences to help frame problems critical to the future of their discipline
6. Demonstrate an ability to conduct original research and communicate it to their peers

PEOPLE

FACULTY

PROFESSORS
Blanchard, Bonazza, Bronkhorst, Crone, Hegna, Henderson, Lakes, Schmitz, Smith, Sovinec, Waleffe, Wilson (chair)

ASSOCIATE PROFESSORS
Allen, Witt

ASSISTANT PROFESSORS
Choy, Couet, Geiger, Franck, Notbohm, Thevamaran

AFFILIATE PROFESSORS
Bednarz, Bier, Engle, Graham, Kolkowitz, Ludois, Ma, Miller, Morgan, Nellis, Pfotenhauer, Porter, Prabhakar, Robertson, Szlufarska, Thomadsen, Trujillo, Vanderby

EMERITUS PROFESSORS
Abdel-Khalik, Bisognano, Callen, Carbon, Conrad, Cook, Corradini, DeLuca, Drugan, Emmert, Fonck, Hershkowitz, Kammer, Kulcinski, Mackie, Malkus, Moses, Plesha, Sandor, Schlack, Vogelsang