Nuclear Science & Engineering
Course 22

The students, professors, and research staff of the MIT Department of Nuclear Science and Engineering (NSE) study nuclear reactions and radiation, their applications, and their consequences. We generate, control, and apply nuclear reactions and radiation for the benefit of society and the environment. Today our Department is working to make nuclear power the safest, most economical, and most environmentally benign source of energy, while also laying the foundations for exciting new applications of nuclear and radiation science and technology. As one of the world's leading academic departments in our field, we also have a responsibility to inform public debates on the wise, humane uses of nuclear science and technology.

Members of our department are making important contributions to the engineering of fission power reactors, to thermonuclear fusion and plasma physics, and to monitoring, detecting, and securing nuclear materials. Current research includes the development of new tools for modeling and controlling complex nuclear and radiation processes, the design of new materials with enhanced performance in radiation fields, the use of coherent control to engineer radiation sources and more precise measurement instruments, and new generations of nuclear fission and fusion reactors.

Our department enjoys extensive research and educational collaborations with industry, with the federal government and the national laboratories, and with partners in several other countries, including Japan, France, Korea, China, UAE and Russia, providing our students with many opportunities for study and research overseas.

Areas of research and instruction in the department include:

- Advanced reactor design and development
- Fuel cycle technology and economics
- Plasma physics and fusion
- Coherent control and quantum information processing
- Materials in radiation environments
- Advanced computation and simulation
- Nuclear security

Undergraduate Program

The undergraduate program in Nuclear Science & Engineering offers flexible subject combinations to satisfy individual student preferences. Several sample roadmaps lay out various paths forward depending on student interest and plans after graduation. In addition to the basic nuclear science and engineering education, pathways are available in nuclear energy, fission reactor physics and design, medical applications of radiation (including preparation for medical school), plasmas and fusion (NSE and Physics double major), quantum engineering (NSE and Physics double major), nuclear materials (NSE and Materials Science and Engineering double major), and nuclear security and policy (NSE and Political Science double major). Each pathway provides specific possibilities for student outcomes, but all also provide strong preparation for a broad range of technical and nontechnical careers. All the pathways lead to the SB in Nuclear Science and Engineering.

In the field of fission energy, undergraduate classes provide multi-disciplinary depth in fission engineering, including entry-level graduate courses in the senior year. Classroom work focuses on applications of fission reactions to understand and design systems for producing energy from the nucleus. Topics include advanced nuclear power reactors with emphasis on safety, reliability, and economic competitiveness, nuclear waste disposal, and nuclear applications 'off-the-grid' such as space nuclear propulsion and the provision of process heat for enhanced oil recovery.

In the field of fusion energy and plasma physics, classroom work and research focus on the physics and engineering of fusion reactors. The sun and stars are powered by fusion. If this energy source can be harnessed at human scale, it will have the advantages of inexhaustible fuel resources and reduced environmental concerns. Yet fusion reactions occur only at temperatures comparable to the center of the sun. So implementing a fusion

reactor requires techniques to create and confine the immensely hot, ionized, 'plasma' state of matter.

NSE also provides opportunities for students to study the rapidly growing field of quantum engineering. Though not yet a household term, the impact of quantum engineering on life in the 21st century may be far-reaching. This emerging field has the potential to revolutionize computing, precision measurement, materials science, and many other fields by harnessing the complex and often-baffling properties of sub-atomic particles. The goal is to gain control over individual sub-atomic quanta, and use them as functional devices, including 'qubits', or quantum representations of information. Students following the fusion/plasma physics and quantum engineering pathways may take double majors in Nuclear Science and Engineering and Physics.

Study in the field of nuclear security explores the connections between nuclear energy and nuclear security, and policies for safe and secure management of nuclear materials, nuclear technology, and nuclear weapons. Students are introduced to both strategic and technical aspects of the problem, including advanced technologies for detection of special nuclear materials, explosives, and other sensitive materials, as well as applications of risk assessment methodologies to nuclear security problems. Students following this pathway may double major in Political Science or Physics.

The medical applications pathway explores the important contributions of nuclear science and engineering to medicine while preparing students for entry to medical school.

In all these areas, students are educated in a combination of the departmental curriculum and MIT's General Institute Requirements (GIRs). The departmental piece includes work in math and science beyond the GIRs, subjects covering broadly applicable engineering principles, subjects related to nuclear science and engineering specialties, and research leading to an individual student thesis.

Research

Challenging research projects are conducted by faculty, students, and staff in the department. Many undergraduates participate in those projects through MIT's Undergraduate Research Opportunities Program (UROP). The department also offers a UROP to any Freshman interested in Nuclear Science & Engineering. Undergraduates participate in research at the MIT Plasma Science and Fusion Center (PSFC), at the Center for Advanced Nuclear Energy Systems (CANES), and at the MIT Nuclear Reactor Laboratory (NRL). Experiments on the six megawatt reactor at the NRL are used for research and teaching support and for student operator job opportunities for undergraduates.

Post Baccalaureate Opportunities

About half of the department's undergraduates continue their studies at the graduate level in engineering or medicine, with the rest finding profitable employment in the nuclear industry, in other energy companies, in government, at national laboratories, in hospitals, or in a wide range of other sectors. Some students opt for military service after graduation.

Qualified undergraduates are eligible for graduate study through the department's five-year double nuclear science and engineering undergraduate and master's degree program. MIT undergraduates extend the duration of on-campus work for one year. The Department also offers a Nuclear Engineer graduate degree and Ph.D. degree programs in all nuclear science and engineering fields of study.

Contact Information

To obtain further information about nuclear science and engineering at MIT visit http://web.mit.edu/nse, or contact Professor Dennis Whyte, MIT, 77 Massachusetts Avenue, Room NW17-105, Cambridge, MA 02139-4307, 617-253-1748. To learn more about NSE's sample undergraduate roadmaps, visit http://web.mit.edu/nse/education/undergrad/roadmaps/index.html

The MIT Bulletin, Courses and Degree Programs Issue, contains further information on the Institute, including all graduate and undergraduate courses and programs. For details on ordering the course catalogue, please visit the MIT Press Bookstore website at http://mitpress.mit.edu/bookstore/bulletin.html.

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