

Nuclear Science & Engineering

Course 22

Nuclear Science & Engineering is the branch of engineering concerned with applications of interactions between nuclei, molecules, and radiations. Nuclear technology is a major contributor to the vitality and health of society with its widespread use for electricity generation and industrial and medical diagnostics, and as an indispensable tool for scientific research in fields ranging from pharmaceuticals to environmental studies. In the future, nuclear technology promises to contribute to address society's global climate change challenges by the use of greenhouse gas emission free nuclear energy, by expanding technical innovations in nuclear science and technologies and by solidifying medical diagnostic and therapeutic breakthroughs.

Nuclear Science and Engineering at MIT

During the 1940s and 50s, MIT contributions to the teaching and development of nuclear science and technology came from several laboratories and departments in the School of Science and the School of Engineering. During that time, a curriculum of graduate study in nuclear engineering was developed and expanded within the Department of Chemical Engineering.

In 1953, the first degrees of Master of Science in Nuclear Engineering were awarded. In 1958, the first Doctor's Degree in Nuclear Engineering was granted. In the same year, the Department of Nuclear Engineering was made a separate department. During the early growth years after its founding, the scope of the department's attention was broadened to include many aspects of topics of continuing interest (such as those in fission power, biomedical research, and thermonuclear plasmas). The department's instructional program was expanded to the undergraduate level, first by adding subjects, then by providing a complete program leading. The enrollment in the Department of Nuclear Engineering in all facets of study presently includes about 115 graduate students and 50 undergraduates.

Undergraduate Program

The undergraduate program in Nuclear Science & Engineering offers various subject combinations to satisfy individual student preferences. In addition to the basic nuclear science and engineering education, students are offered courses in fission energy, nuclear science and technology, nuclear biomedical engineering and a path to become medical doctors. The undergraduate educational objective is to have graduates from the department capable of entering multiple fields from energy, nuclear science and technologies which include industrial and medical applications, fusion research, policy and medicine. Optional subject selections are available in the later stages of the undergraduate experience to permit concentrating on particular specialties of interest.

In the field of nuclear energy, undergraduate classroom work is mostly concerned with applications of the fission reactions to understand how power is produced from the nucleus. During recent years this work has focused on advanced nuclear power systems, nuclear waste disposal techniques, nuclear applications for process heat including enhanced oil recovery. Some projects are devoted to improving the performance of the existing light water reactors (LWRs). The bases of such improvements include development of performance-based safety regulation, contributions to power station operational availability, and reduction of operating and maintenance costs. Other research projects involve continuing work on advanced reactors, with emphases upon simplification and upon increasing the reliability of the cooling function for large light water reactors. Most recently, the development of the Next Generation Nuclear Plant which is a high temperature helium cooled reactor and space nuclear power have captured the imagination of students. The department has established a Center for Advanced Nuclear Energy Systems through which much of this work is performed.

The other major area of study is called Nuclear Science and Technology which deals with the application of nu-

clear processes to the medical and industrial fields. Ongoing research in this area includes medical diagnostic techniques (nuclear magnetic resonance [NMR], positron emission tomography [PET], neutron imaging, etc.); molecular neuroimaging and neuroscience systems; radiation therapy, biophysics, and radiation health physics (neutron capture therapy for cancer and arthritis, design and applications of particle accelerators for biomedicine, etc.); characterization and modeling of material behavior through radiation; and use of neutron tomography and gamma-ray imaging for many industrial purposes (e.g., explosives' detection at airports and ports of entry). A new area for the department is the development of quantum information processing systems and atomistic simulation of materials to better understand their properties from fundamental principles.

In both areas, students are educated in a combination of the departmental curriculum and MIT's General Institute Requirements. The departmental piece includes work in math and science beyond the GIRs, subjects covering widely applicable engineering principles, subjects related to nuclear engineering specialties, and research leading to an individual student thesis. NSE students often take on double majors in Physics, Economics or Mechanical Engineering.

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. Areas of possible undergraduate involvement include research in the MIT Plasma Science and Fusion Center (PSFC) and in the MIT Nuclear Reactor Laboratory (NRL). Current work includes the design of superconducting magnets and the conduct of experiments using the MIT Alcator C-Mod tokamak facility. Experiments in the five megawatt reactor in the NRL are used for research and teaching support and for student operator job opportunities for undergraduates.

Post Baccalaureate Opportunities

The undergraduate program in the MIT Department of Nuclear Science & Engineering prepares students for careers in nuclear energy or in applied radiation (including medical technology). The program also prepares

students for graduate study in nuclear engineering and related disciplines (including entry into medical school). About half of the department's undergraduates continue their studies at the graduate level in engineering or medicine with the rest finding profitable employment at national laboratories, industry, nuclear vendors and utilities, hospitals and even companies outside the nuclear field such as investment banks.

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 1 year. The Department also offers a Nuclear Engineer graduate degree and a Ph.D. program in all nuclear science and engineering fields of study.

Contact Information

Further information about nuclear engineering at MIT may be obtained from the World Wide Web at <http://web.mit.edu/nse> or from Professor Andrew C. Kadak, MIT, 77 Massachusetts Avenue, Room 24-202, Cambridge, MA 02139-4307, (617) 253-0166.

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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