Graduate Studies in Engineering Physics at McMaster University

Engineering Physics is the investigation and application of fundamental principles of physics to create the next generation of technology. We are pushing the forefront of modern physics to better the world through technological advancement. We are solving the grand challenges of the future such as energy supply, human health, digital information and communications technology, and renewable energy. Students can choose among a variety of research specializations including biomedical engineering, nuclear engineering and energy systems, nano- and micro-devices, and photonics.

For more information: **http://engphys.mcmaster.ca/**

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Biomedical Engineering

McMaster University is renowned for its research and education programs in the fields of Health Sciences and Engineering. In partnership with the Faculty of Health Sciences, the Faculty of Engineering recently established a new Integrated Biomedical Engineering and Health Sciences undergraduate program, which is complemented by graduate programs in the McMaster School of Biomedical Engineering. McMaster's Department of Engineering Physics combines facilities for fabricating nano- and micro-devices and facilities for performing biochemical and biological experiments. McMaster's Biointerfaces Institute, Centre for Emerging Device Technologies, and the Canadian Centre for Electron Microscopy provide state-of-the-art facilities to integrate electronic devices with biological cells and molecules, and to study the interfaces of these very different materials with atomic resolution. These fundamental studies are helping us create more effective and versatile biosensors. Our department is creating biosensors that are similar to glucose monitors in terms of ease-of-use and cost but can be applied to various diseases like heart disease, cancer and infectious diseases. Our department is also the leader in biophotonics, which involves the development and application of optical techniques, particularly imaging, to the study of biological molecules, cells and tissues.

- Our faculty use the Canadian Centre for Electron Microscopy, featuring Canada's first electrochemical liquid cell, which allows us to study the interaction of liquids with electronic devices. Our faculty, for example, are studying the deposition of DNA on solid surfaces for electronic biosensors.
- The Biointerfaces Institute features high throughput facilities for creating conductive and bio-active inks. Our faculty are currently using these for creating printable electronic biosensors.

- Our faculty are working on optical spectroscopy and imaging techniques for biomedical applications. Current projects include development of high throughput robotic microscopic imaging systems for screening of cancer drugs; endoscopic optical biopsy systems for screening of cancers in the gastro-intestinal track; non-invasive, intra-operative detection of brain tumor margins; and micro- and nano-devices for imaging and sensing.

Nuclear Engineering and Energy Systems (We are Canada's Nuclear University)

Canada has several, small "Slowpoke" nuclear reactors (20 kilowatts) at École Polytechnique (Montreal), University of Alberta (Edmonton), Saskatchewan Research Council (Saskatoon), and the Royal Military College (Kingston). However, McMaster University's nuclear reactor is 250x more powerful. Ours is the only large (5 Megawatts) nuclear reactor on a University campus, in operation since 1959. It is the second largest nuclear reactor at a University in North America. Bertram Brockhouse (Physics Nobel Laureate) completed some of his ground-breaking work on neutron scattering using McMaster's nuclear reactor. This facility continues to enable unique research and education in nuclear technology:

- Led by Engineering Physics faculty, McMaster's nuclear reactor produces a high energy positron beam used to probe defects in materials.
- Led by Engineering Physics faculty, McMaster's Centre for Advanced Nuclear Systems (CANS) studies and develops new materials for the next generation of nuclear reactors. This lab will be the only one of its kind located on a university campus, in terms of size and capability to handle irradiated materials from nuclear power reactors.
- Engineering Physics students perform experiments in the campus reactor, including approach to criticality experiments, xenon transient experiments, and neutron flux detector experiments.
- Engineering Physics students conduct research in nuclear safety analysis, nuclear waste disposal, and nuclear physics.
- Continuing the work of Bertram Brockhouse, McMaster's nuclear reactor provides an intense beam of neutrons used for neutron scattering experiments to probe the structure of materials.
- Did you know that jet engine blades are composed of a single crystal of nickel alloy? Almost all of the jet engine turbine blades manufactured in North America are tested at McMaster's nuclear reactor using neutron radiography. Neutron radiography takes a picture of objects, similar to an X-ray, and enables internal flaws such as minute cracks or defects to be detected.
- McMaster's nuclear reactor manufactures ~60-70% of the world's Iodine-125, used for the diagnosis and treatment of prostate cancer.
- McMaster's nuclear reactor provides neutron activation analysis, which is a technique used to detect extremely small amounts of elements in a sample, and is used extensively by the mining industry.

- McMaster is the leading institution in North America for performing nuclear safety analysis, making nuclear reactors safer and more efficient.
- McMaster's reactor is the only campus reactor in the world with a containment structure, using slip-form concrete that was later adopted by Canada's nuclear power industry.

We are Canada's "Nuclear University".

Sustainable energy systems are also studied in Engineering Physics. Sustainable energy is the assessment of current and future energy systems, covering resources, extraction, and conversion with emphasis on meeting regional and global energy needs in a sustainable manner. In addition to nuclear energy, the department specializes in photovoltaic energy (solar electricity), which is the conversion of sunlight to electricity.

We are McMaster's "Photovoltaic Department"

Nanotechnology, Nano- and Micro-Device Engineering

McMaster's Department of Engineering Physics has world-class facilities for fabricating nano- and micro-devices, including the Centre for Emerging Device Technologies, and the Canadian Centre for Electron Microscopy. Devices that are constructed on the nanometre or micrometre scale are the technological backbone of the modern age of computers and high-tech communications. Since the introduction of the integrated circuit in the 1960's, device components have decreased in size and cost at an exponential rate, while increasing in speed and capabilities. The rapid advances in computer capabilities have transformed the worldwide economy and have led to a more prosperous society. The invention of the transistor in 1947 is an example of an engineering feat that has changed the world, leading to a $500 billion a year industry in integrated circuit fabrication. In Engineering Physics, students gain an understanding of device science and engineering through hands-on device fabrication.

Our department is the leader of micro-electro-mechanical systems (MEMS), which are small integrated devices or systems that combine electrical and mechanical components. They range in size from the sub-micrometer level to the millimeter level, and there can be any number, from a few to millions, in a particular system. MEMS extend the fabrication techniques developed for the integrated circuit industry to add mechanical elements such as beams, gears, diaphragms, and springs to devices. Examples of MEMS device applications include inkjet-printer cartridges, accelerometers, miniature robots, micro-engines, inertial sensors, micro-mirrors, micro-actuators, optical scanners, fluid pumps, transducers, and chemical, pressure and flow sensors. New applications are emerging as the existing technology is applied to the miniaturization and integration of conventional devices.

Photonics Engineering

Photonics is the branch of science and engineering that involves the generation, control, and detection of light to provide useful applications for society. In the past two decades, Photonics

Engineering has emerged as an important new discipline, partly due to an explosive growth in fibre optic communications. The application of light also extends to many other industries such as medicine, biophotonics, sensors, displays, solar cells, nanotechnology, manufacturing, and traditional optical engineering. Laser light is one of the greatest inventions of the past century, with significant impact on modern life. From manufacturing to medicine, the application of light is everywhere. In Engineering Physics, an understanding of the science behind the application of light is gained through research that explores concepts from a theoretical and an applied industrial perspective.