

Certificate in Imaging Science & Engineering (IS&E)

Washington University has been a leader in imaging science research for more than four decades, with many new medical imaging modalities, advanced applications in planetary science, and fundamental theories having been developed here. The Imaging Sciences Pathway (<https://sites.wustl.edu/imagingsciences/>) in the Division of Biology and Biological Sciences in Arts & Sciences is jointly administered with the McKelvey School of Engineering, with students pursuing degrees in departments across the university. The Imaging Science & Engineering (IS&E) certificate program complements the Imaging Sciences Pathway for students in the departments of Electrical & Systems Engineering, Biomedical Engineering, Computer Science & Engineering, Mechanical Engineering & Materials Science, Chemistry, Physics, and the Division of Biology and Biological Sciences. Each department has its own requirements, but all include the IS&E seminar. The program is flexible, so students are encouraged to appeal to the program director to identify individualized programs.

The IS&E certificate program is built on the strengths of imaging science throughout the university. This multidisciplinary program is constructed to expose students to the breadth of imaging research activities at Washington University. There has been an explosion of both increased bandwidth of existing imaging systems and new sensing modalities. The increase in bandwidth from sensors drives innovations in computing, image reconstruction and image understanding. New sensing modalities present unique opportunities for young researchers to make fundamental contributions.

Medical imaging continues to comprise the largest set of applications at Washington University. The resolution of modern whole-body imaging sensors has revolutionized medicine. The development of new portable imaging modalities broadens the impact by lowering cost. Imaging science includes understanding of the underlying physical, biological and chemical processes that yield signals of interest. Microscopes, visible/infrared cameras, magnetic resonance, X-ray, ultrasound and nuclear sensors provide the data used for imaging or inferring underlying processes. Imaging supports clinical diagnosis, radiation oncology, and molecular and neural imaging.

Imaging supports advances in earth and planetary science, enabling discovery from rovers on Mars, characterizing surface properties from satellites, and inferring internal phenomena in planetary objects. Modern understanding of materials science is driven in part by new imaging methods. New imaging systems for plant science seek better characterization of their biological systems.

Data rates from imaging systems demand efficient processing, manipulation and representation. In modern imaging systems, computing and sensing often must be jointly optimized. Inference is typically based on searching for meaningful patterns in the data, along with the relative contributions of those patterns.

For more information, please refer to the Department of Electrical & Systems Engineering website (<http://ese.wustl.edu/>) or contact the department directly.

Entering and Completing the Program

Graduate students in participating departments may apply for admission to the IS&E program. Admission requires graduate standing in a participating department, a demonstrated interest in aspects of imaging, and approval of the program director.

Upon being awarded a graduate degree by their home department and completing certain requirements of the program, students are awarded a certificate indicating their successful participation in the IS&E program in addition to having completion of the certificate program posted on their official transcript. The requirements for receiving a certificate are acceptance into the IS&E program, completion of four imaging courses approved by the program director, completion of the requirements for a graduate degree in the student's home department, and participation in the IS&E seminar required for all students in the IS&E program.

Seminars by faculty in imaging science, others at Washington University, and experts from outside the university convey new developments and directions in the field of imaging science and its applications. These seminars also provide the opportunity for interactions among those involved in the program.

Courses of Instruction

Fundamentals underlying imaging science and engineering and the application of these fundamentals to contemporary problems of importance form the theme of the program. Relevant courses come from across the university. The program is flexible, allowing students — in consultation with their advisers and the program director — to design a program that is best for them. Below are representative courses that students in the program take.

Courses in the Imaging Sciences Pathway in the Division of Biology and Biological Sciences

- ESE 596 Seminar in Imaging Science and Engineering/CSE 596/BME 506/Physics 596 **(required)**
- BME 530A Molecular Cell Biology for Engineers
- ESE 589 Biological Imaging Technology/BME 589
- BIOL 5068 Fundamentals of Molecular Cell Biology
- BIOL 5146 Principles and Applications of Biological Imaging
- BIOL 5147/Chem 5147 Contrast Agents for Biological Imaging

Courses in Electrical & Systems Engineering

- ESE 438 Applied Optics
- ESE 520 Probability and Stochastic Processes
- ESE 524 Detection and Estimation Theory
- ESE 582 Fundamentals and Applications of Modern Optical Imaging
- ESE 585 Optical Imaging
- ESE 586A Tomographic Imaging
- ESE 587 Ultrasonic Imaging Systems
- ESE 588 Quantitative Image Processing
- ESE 589 Biological Imaging Technology
- ESE 591 Special Topics: Biomedical Topics I: Principles
- ESE 592 Special Topics: Biomedical Topics II: Imaging
- ESE 596 Seminar in Imaging Science and Engineering **(required)**

Courses in Computer Science and Engineering

- CSE 517A Machine Learning
- CSE 546T Computational Geometry
- CSE 554A Geometric Computing for Biomedicine
- CSE 596 Seminar in Imaging Science and Engineering **(required)**

Courses in Biomedical Imaging

- BME 502 Cardiovascular MRI — Physics to Clinical Application
- BME 503A Cell and Organ Systems Biology
- BME 504 Light Microscopy and Optical Imaging
- BME 506 Seminar in Imaging Science and Engineering **(required)**
- BME 530A Molecular Cell Biology for Engineers
- BME 589 Biological Imaging Technology
- BME 5907 Advanced Concepts in Image Science
- BME 591 Biomedical Optics I: Principles
- BME 592 Special Topics: Biomedical Topics II: Imaging
- BME 596 Seminar in Imaging Science and Engineering **(required)**

Courses in Physics, Chemistry, and Psychology

- Physics 534 Magnetic Resonance
- Physics 589 Selected Topics in Physics I
- Physics 590.1 Seminar-Physics of Ultrasonic Imaging in Cardiovascular Medicine
- Chem 5762 Electron Spin Resonance
- Chem 576 Magnetic Resonance
- Chem 435 Nuclear and Radiochemistry Lab
- Chem 436 Introduction to the Atomic Nucleus
- Chem 578 Nuclear Magnetic Resonance Spectroscopy
- Psych 4450 Functional Neuroimaging Methods

Website: <https://ese.wustl.edu/graduate/degreeprograms/Pages/graduate-certificate-imaging-science-engineering.aspx>