This course provides students with a broad background in imaging approaches and their application in biomedical research and development. Topics include imaging system theory, imaging physics, microscopy, ultrasound imaging (US), magnetic resonance imaging (MRI) and computed tomography (CT). Associated laboratory modules teach students to design, conduct, and analyze imaging experiments, and to use the techniques, skills and tools necessary for biomedical research and development.

The course aims at Bioengineering undergraduate students. Prerequisites are BIOEN 3101: BioSignals Analysis and BIOEN 3301: Computational Methods. Participation of students from other departments and graduate students requires permission by the instructors.

**Topics Covered**

**Imaging System Theory**
- Linear Systems
- Fourier Transformation
- Digitization and Sampling
- Convolution and Correlation
- Projections

**Basic Optics**
- Geometrical Optics
- Reflection/Refraction
- Interference
- Diffraction
- Optical Resolution
- Fluorescence

**Microscopy**
- Optical Microscopy
- Fluorescence Labeling and Imaging
- Confocal Microscopy
- Super Resolution Microscopy
- Electron Microscopy
- Processing and Analyzing of Microscopic Images

**MRI**

**X-Ray**

**CT**

**US Imaging**

**Labs**
1. Processing and visualization of microscopic images (Image), Rendering software
2. Computational lab “3D convolution and deconvolution”. Students will use MatLab.
3. Hands-On lab “Fluorescence and confocal microscopy”. Lab will be at Imaging core or CVRTI.
4. US lab “Introduction to hardware, acquisition and analysis”
5. MRI lab “Introduction to hardware, safety, acquisition and reconstruction”. Students will use software for quantitation of MR data, eg T2 fitting. Lab will be at Small Animal Imaging Facility.
6. CT lab “Introduction to hardware, acquisition, reconstruction, and Hounsfield calibration” Students will use software for quantitation of CT data. Lab will be at Small Animal Imaging Facility.
Learning Objectives
To provide students with
• a fundamental knowledge of imaging theory
• an understanding of imaging technology from an engineering perspective
• a solid foundation for application of imaging approaches in biomedical studies

Literature
Fundamentals of Light Microscopy and Electronic Imaging
Douglas B. Murphy, Michael W. Davidson

Essentials of In Vivo Biomedical Imaging
Simon R. Cherry, Ramsey D. Badawi, Jinyi Qi

Grading
Six lab reports. Each lab report contributes 10% to the overall score.
Midterm exam. The exam contributes 20% to overall score.
Class project. The project contributes 20% to overall score.