

**Course Title:** Bioen420 – Medical Imaging

**UW General Catalogue Course Description:**

Physics principles of various medical imaging modalities (x-rays, CT, MRI, ultrasound, PET, SPECT, etc.) and their applications in medicine. Extends basic concepts of signal processing (BIOEN 303) to the two and three dimensions relevant to imaging physics, image reconstruction, image processing, and visualization.

Prerequisite: BIOEN 303; MATH 308; CSE 143.

**Instructor(s)/TA:** Yuan, Chun; Kerwin, William

**Detailed Course Description:**

Bioen 420 – (4 credits). This course introduces the physical principles of imaging methods in medicine. Medical imaging systems to be analyzed include conventional X-ray, computed tomography (CT), magnetic resonance imaging (MRI), nuclear medicine (PET and SPECT), and ultrasound. Each of these modalities will be introduced from basic physical principles to the process of image formation. Also, basic concepts in medical image processing and analysis, as well as medical applications, will be introduced. The course includes three hours of lecture per week and four laboratories that will involve actual medical imaging devices. A course project will be needed that allow students to explore real world applications of the course material.

**Prerequisites by Topics:** Linear Algebra, Signal Processing, Physics 225

**Textbook:**

- Medical Imaging Physics – Fourth Edition, W.R. Hendee, E. R. Ritenour. Wiley-Liss Inc. 2002.

Reference texts:

- Fundamentals of medical imaging, Paul Suetens, Cambridge University Press, 2002.
- The Physics of Diagnostic Imaging D.J. Dowsett, PA Kenny and R.E.

Johnston. Chapman & Hall Medical, 1998.

**Course Objectives:**

- Learn the different methods and modalities used for medical imaging.
- Learn the preferred medical imaging methods for routine clinical applications.
- Understand the engineering models used to describe and analyze medical images.
- Apply these tools to different problems in medical imaging.
- Implement methods to analyze medical images as part of a term project

**Topics Covered:** Physics of X-Ray, CT Nuclear Medicine, MRI, Ultrasound

**Class Schedule:**

- Lectures 1 hour20 min/lecture, meet twice a week
- Labs 4 3-hour labs, the schedule will be determined at the beginning of the quarter

**Course Structure:**

The course employs lectures, 4 laboratories, homework, 2 examinations and a final project.

**Laboratory Work:**

There will be a total of 4, 3-hours labs as follows: 1) CT lab – students will witness CT imaging of subjects and review sample images of different medical applications; 2) nuclear medicine lab – students will listen to a lecture of PET/SPECT imaging and be shown hardware for generating nuclear tracers and for PET and SPECT imaging, as well as sample images from clinical imaging; 3) ultrasound lab – students will witness ultrasound image acquisition and experiment with a variety of hands-on ultrasound probes; and 4) MRI lab – students will witness MRI image acquisition and the effects of changes in the imaging sequences on image characteristics. They will also conduct imaging on volunteers.

**Term Project:**

The term project requires the student to either 1) identify, formulate, and solve a specific problem in medical image processing, or 2) use a nuanced and integrated understanding of biology, physiology, advanced mathematics and engineering to explore new applications of medical imaging to a specific organ centered disease. If the first project is chosen, the student should review an existing algorithm for medical image processing, demonstrate its use, and suggest possible avenues for improving it. If the second project is chosen, the student should review what information can be obtained from each imaging technique for a specific organ/disease, identify the latest research thrusts within that area, and recommend imaging applications for a patient with the specified disease. The projects will be shared with the class in a 10 minute presentation and in a written report. Student presentations – Students will give 10 minute reviews of their term projects

#### **Computer Resources:**

The student laboratory has ten PC workstations with relevant image processing and statistical software such as Matlab, Mathcad, Splus, SAS etc. The students use the computers to develop and validate their algorithms. The department has ten additional computers in a nearby laboratory. Both groups of computers are equipped with Windows 98, Office, and Matlab.

#### **Course Outcome and Assessment and Relationship of Course to Departmental Objectives:**

This course introduces upper level undergraduate students to the interdisciplinary nature of the medical imaging field. Students are expected to understand the basic science behind all major medical imaging modalities and techniques, and to assess the potential applications of these modalities and techniques to complex research and clinical situations. Satisfactory completion of this course requires the student to demonstrate the following skills:

*High level:*

- Ability to apply knowledge of mathematics, science, and engineering to coursework.
- Ability to communicate research results concisely, succinctly, and effectively, both in writing and orally.
- Ability to identify, formulate, and solve engineering problems.
- Demonstrate an interdisciplinary understanding of imaging in the context of biology, physiology, and capability to apply advanced mathematics (including differential equations and statistics), science, and engineering to solve the problems at the interface of engineering and biology.

*Medium level:*

- Ability to understand the basic principles of medical imaging and their main applications.