**BIM 243: Radiation Detectors for Biomedical Application**

Instructor: Prof. Simon Cherry

**Description:**
This course will cover radiation detectors and sensors that operate in the optical, x-ray and gamma-ray regions of the electromagnetic spectrum and particle detectors suitable for detecting electrons. These detectors are widely used in a range of important biomedical applications, including medical imaging, optical microscopy, electron microscopy, spectroscopy, optical sensing, autoradiography, radiation measurement and radiation protection. Devices covered in the course include charge-coupled device (CCD) cameras, photodiodes, photomultiplier tubes, ionization chambers, proportional counters, scintillation detectors and digital imaging plates. The basic physics underlying radiation detection and measurement will be introduced and for each technology, physical principles of operation, design principles and biomedical applications will be discussed. At the end of this course, students will have a firm foundation in the fundamentals of radiation detection, the technology that is available for radiation measurement and the applications of this technology in the biomedical arena.

**Units:** 4
Lecture
Class meets twice per week, for two hours each time
Offered alternate years only – in Winter or Spring

**Grading**
Letter grade based on:
- Homework
- Mid-Term
- Final
- Project

**Syllabus:**
Overview of use of radiation detectors and sensors in biomedical applications

Types of Radiation
- Particulate (electron, proton, alpha particles, heavy ions)
- Electromagnetic (optical, x-rays, gamma rays)

Sources of Radiation
- Units and definitions
- Source of electrons
- Sources of electromagnetic Radiation

Radiation Interactions
Interaction of electrons
Interaction of gamma Rays / X-rays
Interaction of light
Radiation exposure and dose

Counting Statistics and Error Prediction
Statistical models
Applications of statistical models
Error propagation

General Properties of Radiation Detectors
Simplified detector model
Modes of detector operation
Pulse height spectra
Counting curves and plateaus
Gain and amplification
Energy resolution
Detection efficiency
Dead time

Film and Phosphors
Basic principles
Historic use
Limitations

Ionization Chambers
Basic principles
Application in the measurement of radioactivity

Proportional Counters
Basic principles
Detection of electrons and x-rays
Application in autoradiography

Geiger-Mueller Counters
Basic principles
Radiation detection with G-M counters
Application in radiation protection

Photomultiplier Tubes
Basic principles of PMTs
Detection of light
Application in confocal microscopy

Photodiodes and Avalanche Photodiodes
Basic principles of silicon detectors
Detection of light
Application in spectroscopy
Scintillation Detector Principles
   Fluorescence, phosphorescence and scintillation
   Scintillators fundamentals
   X-ray and gamma-ray detection
   Radiation spectroscopy with scintillators
   Application in medical imaging

Semiconductor Detectors for X-rays and Gamma rays
   Germanium detectors
   Cadmium Zinc Telluride
   Amorphous silicon and selenium
   Applications in spectroscopy and medical imaging

Semiconductor Detectors for Light
   CCD Cameras – principles of operation
   Optical and electron microscopy

Imaging Plates
   Principles of operation
   Applications in autoradiography and medical imaging

Thermoluminescent Dosimeters
   Thermoluminescence fundamentals
   Application in radiation dosimetry

Electronics for Radiation Detection
   Pulse processing and shaping
   Linear and logic pulse functions
   Multichannel pulse analysis

Background and Detector Shielding
   Background for light detection
   Background for x-ray and gamma-ray detection
   Shielding

Radiation protection and Health Physics

Uses and relative strengths and weakness of different detectors and sensors in biomedical applications

**Textbook:**

**Radiation Detection and Measurement**

Author: Glenn Knoll
Edition: 4th
Publisher: Wiley & Sons