Goals of the Course
1. Develop a firm understanding of the fundamentals of medical imaging, including an appreciation for the common principles underlying the various modalities.
2. Gain a basic understanding of the physical principles underlying the major modalities, including X-ray, computed tomography, MRI, and ultrasound.

Brief History of Medical Imaging
1895 - Roentgen discovers X-rays
1942 - Dussik demonstrates transmission ultrasound in the brain.
1946 - Bloch and Purcell discover nuclear magnetic resonance (NMR)
1972 - Hounsfield develops the first computed tomography scanner.
1973 - Lauterbur invents magnetic resonance imaging (MRI)
1974 - Ledley develops the first whole body CT scanner.
X-Rays

8 November 1895, Wilhelm Conrad Roentgen discovers X-rays. Receives first Nobel Prize in Physics in 1901.

22 November 1895 X-ray of Mrs. Roentgen’s hand.

X-Ray

An early X-ray imaging system

Computed Tomography

1917 Johann Radon establishes the mathematical framework for tomography, now called the Radon transform.

1963, Allan Cormack publishes mathematical analysis of tomographic image reconstruction. Is unaware of Radon’s work.

1972 Godfrey Hounsfield develops first CT system. Unaware of either Radon or Cormack’s work, develops his own reconstruction method.

1979 Hounsfield and Cormack receive the Nobel Prize in Physiology or Medicine.
Computed Tomography

Virtual Colonoscopy As Good As Other Colon Cancer Screening Methods, Study Finds

ScienceDaily (Sep. 23, 2006) — CT colonography (CTC), known as virtual colonoscopy, is as accurate at screening for colorectal cancers and pre-cancerous polyps as conventional colonoscopy, the current screening standard, according to the National CT Colonography Trial, a nationwide multi-center study that included the San Francisco VA Medical Center.

Siemens Colonoscopy
Non-invasive Colonoscopies Using Advanced Technology. From Siemens.

www.usa.siemens.com/CT
History of Ultrasound

1942  Dr.Karl Theodore Dussik
Transmission ultrasound investigation of the brain
First published work on medical ultrasonics.

Holmes and Howry, 1955
Subject submerged in water tank to achieve good acoustic coupling.
Image of normal neck.

Automatic scanner, Glasgow, ca 1959. Image shows twin gestation sacs (s) and bladder (B).

Ultrasound Systems

Sonosite 180

Acuson Sequoia
Doppler Ultrasound

3D Ultrasound

History of MRI
1946: Felix Bloch (Stanford) and Edward Purcell (Harvard) demonstrate nuclear magnetic resonance (NMR)

History of MRI
Late 1970’s: First human MRI images
Early 1980’s: First commercial MRI systems
1993: functional MRI in humans demonstrated
Clinical MRI System

3 Tesla Magnet at UCSD

Magnet Image from http://www.fmrib.ox.ac.uk/~stuart/lectures/lecture1/

Image Contrast

Image from Rick Buxton
MR Angiography

Image from R. Buxton

Perfusion Imaging with ASL

Image from E.C. Wang

Cardiac Imaging

Image from http://www.bidmc.harvard.edu/cmrcmr/smash/smash.html

Cardiac Tagging

Image from http://www.mri.jhu.edu/~emcveigh/LabIntro/tagging.html
Functional MRI

Image from http://www.brainvoyager.de/

Diffusion Tensor Imaging

Image from L. Frank

MR Microscopy

Image from http://mouseatlas.caltech.edu/

MR Spectroscopy

Image from http://www.sf.med.va.gov/mrs/ad/result.htm
Molecular Imaging

EgadMe labels regions positive for beta-gal expression

Fluorescence (GFP)

MRI

Bright field

(fixed and stained)

Image from http://quad.bic.caltech.edu/~meadegroup/smart%20contrast%20agents.htm