

# Physics of Diagnostic Imaging II

Course No: RADI 6016  
Instructor: Jack L. Lancaster, Ph.D.

Semester: Spring  
Day/Time: Tues/Thur 8:00-9:30  
Room: RII Seminar Class Room (2.534)

Text: Handouts from revisions of:  
The Physics of Medical X-Ray Imaging, 2nd Ed  
Author: Bruce H. Hasegawa, Ph.D.

Credits: 3 hr (3 - lecture, 0 - lab)

## Recommended References:

1. Evans A Li, The Evaluation of Medical Images, Medical Physics Handbook 10, Adam Hilger Ltd, Bristol, 1981.

Easiest to read.

2. Krestel Erich, Ed, Imaging Systems for Medical Diagnostics, Siemens, Berlin, 1990.

Broadest Coverage of Imaging Equipment and parameters. Available in Radiological Sciences office.

3. Barrett, Swindell W, Radiological Imaging - The Theory of Image Formation, Detection, and Processing, Vol 1 & 2, Academic Press, New York, 1981.

Most mathematical, concentrates on nuclear medicine imaging.

## Software:

**Mango** (<http://ric.uthscsa.edu/mango/>) image processing software will be used to present examples for most chapters. Additionally, students will learn how to use Mango to make measurements, and its FFT plug-in to better understand the relationships between spatial and Fourier domain images.

## Grading Scheme:

Homework	30%
Mid Term Exam	30%
Final Exam	30%
Project	10%

## Course Outline:

Handouts for each chapter are available at the following web site:

[http://ric.uthscsa.edu/personalpages/lancaste/DI\\_II.html](http://ric.uthscsa.edu/personalpages/lancaste/DI_II.html)

This material is continuously updated, so don't print out all of the chapters at the beginning of the semester.

**Chapter 1** - Introduction to the basic concepts of Noise, Resolution, and Contrast as applied to medical images. Development of relationships of these concepts to Signal-to-noise ratio, Modulation Transfer function, and Wiener spectra. Introduction to the system concepts using the Rose model.

**Chapter 2** - Introduction to Electronic Imaging. Review of image intensifier/video system, scintillation detectors, gas ionization detectors, film digitizers, and photostimulable phosphor plate systems.

**Chapter 3** - Digital Imaging in Diagnostic Radiology. Overview of a digital image processing system for x-ray fluoroscopy including image capture, storage, and processing. The digital image and sampling requirements derived from Shannon's sampling theorem.

**Chapter 4** - Physical Determination of Contrast. Components of image contrast attributable to radiographic (subject) contrast, detector contrast, display contrast, and physical perturbations. Review of the physical composition of the major body tissues (adipose, muscle, water, and bone) and corresponding attenuation characteristics. Introduction to contrast media and attenuation characteristics. Contrast of film-screen systems compared to electronic detectors. The effects of scattered radiation on contrast.

**Chapter 5** - Linear Systems. A review of linear systems including such fundamental concepts and the Dirac delta function, convolution and correlation ratios, and the Fourier transform. Development of the mathematical model of x-ray imaging as a linear system. Expansion of the model to a Fourier space description.

**Chapter 6** - Spatial Resolution. Mathematical analysis using the point, line, and edge functions. Description of sources of geometrical unsharpness and their mathematical descriptions. Mathematical description of image digitization process from the analog image through sampling and pixellation to develop the final digital image. Aliasing problems and solutions. The assessment of digital image resolution via the point spread function and the modulation transfer function.

**Chapter 6a** - X-Ray CT. Mathematics of the computed tomography process will be presented. Radon's theory of filtered backprojection will be developed using the Fourier transformation as the basis. Several different CT methods will be presented along with their relationship to the physical properties of imaging instrumentation. Non x-ray methods (SPECT and PET) will be briefly discussed.

**Chapter 7** - Random Processes. Continuous and discrete probability density functions. The binomial, Poisson, and Gaussian distributions, central limit theorem, and propagation of errors.

Chapter 8 - Noise and Detective Quantum Efficiency. Deals with noise and sources of noise in medical images. Quantitation of noise using the signal-to-noise ratio (SNR), and detective quantum efficiency (DQE). Methods for Optimization of SNR and DQE.

**Chapter 8a** - Autocorrelation and Wiener Spectrum. This approach to relating noise and resolution will be presented and classic papers reviewed.

Chapter 9 - The Rose Model. Theoretical development of this model which deals with the relationship between contrast and SNR. Contrast-detail analysis and ROC analysis will also be covered.

Chapter 10 - Digital Subtraction Angiography (DSA). System design considerations. Logarithmic vs. linear subtraction techniques. Analysis of noise in DSA as a function of signal level.

Chapter 11 - Temporal Filtering Techniques. Development of the mathematical methods describing mask mode subtraction, matched filtering, and recursive filtering in DSA.