PHYSICS 782 Physics of Medical Imaging, Spring 2010

Instructor information:

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Office Hours: Mondays 5-6pm; Thursdays 9:15-11am

Time:

42 hours minimum, 3 credits
Mondays: 6-7:15pm in Physics 144
Thursdays: 8-9:15am in Physics 126
NOTE: Classes start Thurs Jan 28, and will not be held the week of Feb 7, but will be held throughout March (during UWM Spring Break). Scan room visits TBD.

Prerequisite:

Calculus-based introductory physics (classical mechanics, thermodynamics, electricity and magnetism, modern physics, or equivalent) and writ. cons. instr. (undergraduate students), or graduate student standing.

Textbook and suggested reading:

Nishimura, *Magnetic Resonance Imaging.*
Kak & Slaney, *Principles of Computerized Tomographic Imaging,*
http://www.slaney.org/pct/pct-toc.html
Hsieh, *Computed Tomography,* SPIE Press.
Zagzebski, *Essentials of Ultrasound Physics,* Mosby, 1996.
Cobbold, *Foundations of Biomedical Ultrasound,* Oxford Univ Press, 2007.
William R. Hendee E. Russell Ritenour, *Medical Imaging Physics,* Wiley, 2002.
Barrett & Meyers, *Foundations of Image Science,* Wiley, 2004.
Bushberg, Seibert, Leidholdt, *The Essential Physics of Medical Imaging.*

Skills and/or knowledge to be acquired

Upon completion of this course, the student is expected to acquire knowledge of the physics of diagnostic radiology using X-rays, magnetic resonance, nuclear medicine and ultrasound, and get acquainted, thorough visits to the equipment rooms, with relevant equipment. This course will partially prepare students for the American Board of Radiology (ABR) Part I examinations; Radiobiology and Radioisotopes courses planned as part of a MS curriculum should also be taken to prepare for ABR Part I.

Grading formula

Written exam	30%
Homework	40%
Individual project	30%

Course outline

1. **Introduction(1):** History of Medical Imaging. Basic principles. Definition of signal, noise, high and low resolution. (1 hour)

2. **Imaging Theory(4):** Gibb's ringing (*1 hour*). Sampling theory (*1 hour*). Impulse response (*1 hour*). 2D Fourier theory (*1 hour*).

3. **Magnetic Resonance Imaging(6):** Echo spin physics (*1 hour*). Bloch equation; signal equation (*1 hour*). Frequency space (K-space) trajectories (*1 hour*). Projection reconstruction (*1 hour – after CT projection-slice*). 2D Fourier transform trajectory (*1 hour*) Image quality contrast; SNR and resolution (*1 hour*). MRI scanner room visit

4. **Projection Radiography(9):** X-ray physics and X-ray tube design (*1 hour*). Attenuation coefficient and scatter (*1 hour*). Source and object magnification (*1 hour*). Principle of digital radiography (DR); flat panel detector and charge-coupled device (*1 hour*). Single-photon counting; time-resolved systems (*1 hour*) Dual energy (*1 hour)* Modeling noise in radiographic system; Radiography SNR (*1 hour*). Application to digital mammography (*1 hour*). Digital mammography system visit (*1 hour*). Digital radiographic and fluorographic room visit

5. **Radiation Interaction Processes in the Patient(2):** Contrast media (*1 hour*). Secondary radiation; methods to decrease secondary radiation (*1 hour*).

6. **Computed Tomography (CT) (6):** Projection-slice theorem; convolution-back projection (1 hour). CT hardware (*1 hour*). Dose vs IQ (*1 hour*) New developments: VCT, dual E, low dose/iterative recon w/emission tomog (*3 hours)* CT scanner room visit.

7. **Ultrasound(8):** Ultrasound echo equation (*1 hour*). Physics of U/S transducer (*1 hour*). Attenuation and TGC (*1 hour)* Fresnel and Fraunhofer diffraction (*1 hour*). Lateral and depth resolution (*1 hour*). Phased array systems (*1 hour*). Contrast agents (*1 hour)* HIFU (*1 hour)* Ultrasound room visit.

8. **Emission tomography(4)** SPECT (*1 hour)* PET(*1 hour*) S/N comparison w/ XR CT & iterative recon (*1 hour*) Functional imaging benefits (*1 hour*) Scan room visit.

9. **Individual project presentation**