

BIOMEDICAL ENGINEERING 325
INTRODUCTION TO MEDICAL IMAGING
FALL 2021 ALAN V. SAHAKIAN

Version 1.4 Sept. 10, 2021

Class Room and Times: Tech. L361, Mon., Wed., Fri. 1:00 – 1:50 pm

Instructor: Alan V. Sahakian, 847-491-3641, e-mail: a-sahakian@northwestern.edu

Office Hours: (Tentative) Mon., Wed., Fri. 2:00-2:50 pm, Tech. room L253 (Associate Dean's office) or M394 (faculty office).

Teaching Assistant: Lexi Fan LexiaoziFan2019@u.northwestern.edu Tentative office hours: M,W,F 10-11 am, room TBA

TENTATIVE SCHEDULE v1.3 (THIS MAY CHANGE)

Week	Dates	Topics	Readings (pp.)
1	Sept. 22,24	Introduction to basic concepts of medical imaging	Ch. 1,2,3,6,7
2	Sept. 27, 29, Oct 1	Generation and Detection of x-rays	(above)
3	Oct 4,6,8	x-ray continued, direct methods, body section radiography	(above)
4	Oct. 11,13,15	x-ray methods continued; Computed Tomography; Biological effects	Ch. 10,11
5	Oct. 18,20,22	Ultrasound: Acoustic fundamentals; Generation and detection of ultrasound	Ch. 14
6	Oct. 25	Ultrasound diagnostic methods; Biological effects	(above)
6	Wednesday Oct 27	Exam 1 Returned and discussed on Friday October 29 (the deadline to drop on Caesar)	
7	Nov.1,3,5	Ultrasound concluded. Starting Radionuclide methods. Project proposals due Monday Nov. 1.	Ch. 15,16,17,18,19
8	Nov 8,10,12	Radionuclide methods continued	
9	Nov. 15,17,19	Magnetic Resonance (NMR/MRI)	Ch. 12,13
10	Nov 22,24 No class on 26	MRI continued. Diagnostic value, statistical performance measures. Nov 25 is Thanksgiving	Lecture notes
11	Nov 29, Dec 1,3	Emerging methods. Graduate student project presentations. All written project reports are due Friday Dec. 3	Lecture notes
12	Thurs. Dec 9	FINAL exam 9:00 to 11:00 am in Tech L361 (comprehensive)	

Tentative Grade Breakdown: Homework: 25%, Exam 1: 25%, Project: 25%, Final Exam: 25%

Prerequisites:

The EA math sequence, some Signals and Systems course covering Fourier concepts (co-registration in BME 305 is OK) Note: Appendix G of the textbook has a review of Fourier Transforms and Convolution; Physics 135-3 (Fields and Waves), or equivalents, or consent of instructor.

Required Text:

The Essential Physics of Medical Imaging, **Third or Fourth Edition**, J.T. Bushberg, J. A. Seibert, E.M. Leidholdt, J.M. Boone, Publisher: Lippincott, Williams and Wilkins, Either the third edition (2012) or fourth edition (2020) is acceptable, but not the first or second. As far as I can tell, the third and fourth edition have only minor differences, for example mentioning COVID. This is an expensive book but is available to rent for about \$60 for the quarter. I would expect the third edition to be cheaper and more readily available on the used market, but the fourth edition will obviously keep its value longer if you plan to hold on to the book.

Reference Texts:

- 1) Principles of Medical Imaging, K. Kirk Shung, Michael B. Smith, Benjamin Tsui, Academic Press, 1992. This has a better coverage of ultrasound fundamentals than the required text, but also has many typos.
- 2) Christensen's Introduction to the Physics of Diagnostic Radiology, Thomas S. Curry, III, James E. Dowdey and Robert C. Murry, Jr., Leigh and Febiger, any edition. This is a classic and has many famous examples which simplify concepts.

Course Description:

Fundamentals of the four most-important clinical medical imaging modalities: X-ray, Ultrasound, Radionuclide, and MRI. The primary focus is on the physical principles, instrumentation methods, and imaging algorithms, however the medical interpretation of images, and the clinical, research and ethical issues in medical imaging are also included where possible to give students a deeper understanding of the development and applications of medical imaging.

Projects:

Each student will individually complete a written report (about fifteen double-spaced pages, including figures and references) on a topic related to the course. In addition, each **Ph.D.** student will give a short (about 15 minute) presentation on his or her project during the final week of class. The choice of project topic is left to the student, but students must submit a short (one-page) proposal of their project to the instructor by Monday, November 1 for approval. The report may be a discussion of a new imaging modality, a new development in a classical modality, a new clinical application, an in-depth review of the history of some modality, a detailed technical discussion of some aspect of a modality (perhaps including a Python, MATLAB or other program), a discussion of a clinical or research imaging problem and solutions, or another relevant topic which you find interesting. **All** students will be responsible for attending the Ph.D. students' oral presentations, and this material will be considered fair game on the final.

Coding:

The lectures include a few coding examples which I write in Python, currently version 3.9. If you'd like to experiment with or modify these you can download the version appropriate for your own machine here: <https://www.python.org/downloads/> Mark Pilgrim's *Dive into Python 3* is an excellent resource: <https://diveinto.org/python3/about.html>

Academic Integrity:

Students in this course are required to comply with the policies found in the booklet, "Academic Integrity at Northwestern University: A Basic Guide". All papers submitted for credit in this course must be submitted electronically unless otherwise instructed by the professor. Your written work may be tested for plagiarized content. For details regarding academic integrity at Northwestern or to download the guide, visit:

<https://www.northwestern.edu/provost/policies/academic-integrity/index.html>

Accessibility:

Northwestern University is committed to providing the most accessible learning environment as possible for students with disabilities. Should you anticipate or experience disability-related barriers in the academic setting, please contact AccessibleNU to move forward with the university's established accommodation process (e: accessiblenu@northwestern.edu; p: 847-467-5530). If you already have established accommodations with AccessibleNU, please let me know as soon as possible, preferably within the first two weeks of the term, so we can work together to implement your disability accommodations. Disability information, including academic accommodations, is confidential under the Family Educational Rights and Privacy Act.

Class Recordings:

This class or portions of this class will be recorded by the instructor for educational purpose and available to the class during the quarter. Your instructor will communicate how you can access the recordings. Portions of the course that contain images, questions or commentary/discussion by students will be edited out of any recordings that are saved beyond the current term.

Prohibition of Recording of Class Sessions by Students:

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University's Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

COVID-19 Classroom Expectations:

Students, faculty, and staff must comply with University expectations regarding appropriate classroom behavior, including those outlined below and in the COVID-19 Code of Conduct. With respect to classroom procedures, this includes:

- Policies regarding masking and social distancing evolve as the public health situation changes. Students are responsible for understanding and complying with current masking, testing, Symptom Tracking, and social distancing requirements.
- In some classes, masking and/or social distancing may be required as a result of an Americans with Disabilities Act (ADA) accommodation for the instructor or a student in the class even when not generally required on campus. In such cases, the instructor will notify the class.

- No food is allowed inside classrooms. Drinks are permitted, but please keep your face covering on and use a straw.
- Faculty may assign seats in some classes to help facilitate contact tracing in the event that a student tests positive for COVID-19. Students must sit in their assigned seats.

If a student fails to comply with the COVID-19 Code of Conduct or other University expectations related to COVID-19, the instructor may ask the student to leave the class. The instructor is asked to report the incident to the Office of Community Standards for additional follow-up.

COVID-19 Testing Compliance Statement:

To protect the health of our community, Northwestern University requires unvaccinated students who are in on-campus programs to be tested for COVID-19 twice per week.

Students who fail to comply with current or future COVID-19 testing protocols will be referred to the Office of Community standards to face disciplinary action, including escalation up to restriction from campus and suspension.

Exceptions to Class Modality:

Class sessions for this course will occur in person. Individual students will not be granted permission to attend remotely except as the result of an Americans with Disabilities Act (ADA) accommodation as determined by AccessibleNU.

Maintaining the health of the community remains our priority. If you are experiencing any symptoms of COVID do not attend class and update your Symptom Tracker application right away to connect with Northwestern's Case Management Team for guidance on next steps. Also contact the instructor as soon as possible to arrange to complete coursework.

Students who experience a personal emergency should contact the instructor as soon as possible to arrange to complete coursework.

Should public health recommendations prevent in person class from being held on a given day, the instructor or the university will notify students.

Support for Wellness and Mental Health:

Northwestern University is committed to supporting the wellness of our students. Student Affairs has multiple resources to support student wellness and mental health. If you are feeling distressed or overwhelmed, please reach out for help. Students can access confidential resources through the Counseling and Psychological Services (CAPS), Religious and Spiritual Life (RSL) and the Center for Awareness, Response and Education (CARE). Additional information on all of the resources mentioned above can be found here:

<https://www.northwestern.edu/counseling/>

<https://www.northwestern.edu/religious-life/>

<https://www.northwestern.edu/care/>