BME/EECS 516 – Medical Imaging Systems – Fall 2016

Course Description:	We'll examine, from a systems perspective, the techniques used to form internal images of (living) human bodies. These imaging systems are used for tasks ranging from cancer detection to basic biophysical and cognitive research, and include planar X-ray and gamma-ray (nuclear medicine) imaging, X-ray tomography, ultrasound, single-photon tomography, positron emission tomography, and magnetic resonance imaging (MRI).
Lecture times:	Tues/Thurs, 3:30-5:00 pm, 1311 EECS
Instructor:	Douglas C. Noll, Ph.D. Professor, Biomedical Engineering and Radiology 2109 Gerstacker (734) 764-9194 dnoll@umich.edu Office hours: 2109 Gerstacker, Tues/Thurs 1:30-2:30.
Prerequisites:	Linear systems theory, Fourier transforms, Digital Signal Processing. EECS 351 is formally listed, but many undergrad DSP classes will be sufficient. The main issue is exposure to spectral analysis, continuous and discrete Fourier transforms, linear system theory, sampling and aliasing. A working knowledge of Matlab will be necessary. If you don't know Matlab, you will have to learn it quickly!
Recommended Texts:	The on-line class notes are pretty complete and thus, there are no required texts. We have a few recommended texts: *Medical Imaging Systems* A Macovski (1983, Prentice-Hall) – on reserve in library. *Principles of Magnetic Resonance Imaging* Dwight Nishimura (2010) – Available from Maria Steele for $25 or at http://www.lulu.com/spotlight/dgn59 *Diagnostic Ultrasound Imaging: Inside Out* Thomas Szabo (2014) Available as an ebook through UM Libraries at http://www.sciencedirect.com/science/book/9780123964878 *Medical Imaging Equipment Theory, 2nd Ed* Richard Aston (2008) (Free electronic copy on course website)
Grading:	15% Homework 60% Projects (20% for each of 3 projects) 25% Final Exam (take home final, tentatively Dec. 15-18th)

Syllabus (subject to change, ver 8/31/16)

Dates	Topic	Readings & Homework
9/6 9/8 9/13 9/15 (½)	Introduction & policies Overview of medical imaging modalities Fourier Transforms (1 week) Review of 1D transforms and systems Spatial transforms 2D transforms and systems Sampling in 2D	Instructor's notes Macovski Chapter #2 HW 1 – 9/13, due 9/20
9/15 9/20 9/22 9/27 9/29 10/4 10/6 10/11	Ultrasound (3.5 weeks) Sound wave propagation, wave equation Attenuation, dissipation and dispersion Resolution issues, speckle noise Huygens principle and diffraction Fresnel and Fraunhoffer approximation Beam forming and focusing Ultrasound transducers, 2D array system Sampling and aliasing	Instructor's notes Macovski Chapter #9-10 Aston Chapter. #6 Szabo Chapters. #3-9 HW 2 – 9/22, due 9/29 HW 3 – 10/6, due 10/13 Proj 1 – 10/11, due 10/25
10/13 10/20 10/27 10/29 11/1 11/3 11/8	Magnetic Resonance Imaging (3.5 weeks) Spin mechanics, excitation, relaxation The Bloch equation The signal equation k-space, sampling, resolution, field of view Pulse sequences Selective excitation, excitation k-space Imaging issues, noise	Instructor's notes Aston Chapter #1 Nishmura Chapters #3-6 **10/18 – Fall break** HW 4 – 10/25, due 11/1 HW 5 – 11/1, due 11/8 Proj 2 – 11/8, due 11/22
11/10 11/15 11/17 ½	X-ray (1.5 weeks) Interaction of photons & matter Attenuation and line integrals	Instructor's notes Macovski Chapter. #3-4
11/17 11/22 11/29 12/1	Computed Tomography (2 weeks) Central Section Theorem Reconstruction algorithms	Instructor's notes Macovski Chapter #7 **11/24 – Thanksgiving** HW 6 – 11/22, due 12/1, Proj 3 – 12/1, due 12/15
12/6 12/8* 12/13	Nuclear Imaging and Misc Topics (1.5 week) SPECT, PET. May take extra time on CT, image reconstruction. Guest speakers from imaging industry (12/8)	Instructor's notes Aston Chapters #4,5
12/15-18	72-hour take-home final exam (times TBD)**	Turn in Project 3 on 12/15

*Guest lecturer.

**Please let me know ASAP if these dates conflict with too many other times for finals.

TBD (after class): Lab tours.

TBD: Other guest lectures

Course and Grading Policies

- Announcements will be made in class or by e-mail through the course website. This will send messages to you umich email account – if you don't use this one, please make sure it forwards to your account or that you provide me with an alternate email address.
- Access to Matlab is a requirement for this course - this is available through computing labs on campus and free licenses are available for engineering students. See: https://www.itcs.umich.edu/sw-info/math/MATLABStudents.html
- Course grades will be assigned on a curve, though in general achieving a 90% or higher should earn a least an A- and 80% of higher should earn at least a B-. No incompletes will be given except as specified by UM policy.
- If you find small mistakes in the grading, I will try to fix those immediately. For a substantial re-grading of your homeworks, projects or exams, I may request that you submit your entire assignment/exam for regrading and your resultant grade may be higher or lower.
- I will discard your lowest homework grade. I recommend that you complete all assignments, but this gives you some flexibility if you need to travel, become ill, etc.
- Generally, late assignments will not be accepted.
- Homework policies:
  - You should attempt to do all homework problems yourself.
  - Only after you have made an attempt to solve the problem on your own may you discuss it with your classmates.
  - After this, you must still write up your own solutions.
  - Actual copying of Matlab code, etc. is strictly forbidden.
  - For computer (e.g. Matlab) assignments, you should upload in the all .m files and hand in your assignment with all plots and figures (with axes labeled).
  - All homework sets are due at the end of class on the due date.
- Project policies
  - You may choose a partner for each project. There will be three projects assigned in this class – you must have a different partner for each project. You may choose not to work with a partner. If you do work with a partner, please put your partner's name on your solutions.
  - I expect you to do your own work, but when you get stuck, you may ask your partner or the instructor for help. Think of this as an exam, but one in which on may ask for help from one other person (and the instructor).
  - Getting help from anyone other than the instructor or your partner or copying solutions (even from your partner) will be considered a violation of the engineering honor code.
  - Each person must hand in his/her own solution.
  - Hand in answers to questions below, all requested plots/graphs/images and copies of your final ".m" files. Grading is based on correct implementation of the assignment and also based on the quality of your written discussion of the project. For each question/task please write a small paragraph about what you did, what equation you implemented, and about the appearance of the resultant images, etc. Say something interesting!
  - Title and label the axes on all plots and images (do this by hand if you like). I deduct points for unlabled figures and graphs.
- Final Exam
  - The final exam will be a take home exam.
  - You may use your notes, web resources, computers, etc.
  - You may not seek assistance or work with anyone else.
  - You are required to abide by the UM Engineering Honor Code. Exams will **not** be graded without a signed honor code statement.