Biomedical Ultrasound Imaging

ECE 472/BIOE 427

Spring 2024

11:00-12:20, Tuesdays and Thursdays, ECEB 2015

Instructor: Pengfei Song, Ph.D. (Assistant Professor)
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Website: https://courses.engr.illinois.edu/ece472/sp2024/

The overall objective of this course is to familiarize the students with most of the theoretical and engineering foundations of biomedical ultrasonic imaging. Conventional, Doppler and selected advanced ultrasonic imaging techniques will be described. Students will be introduced to important applications of the different ultrasonic imaging techniques. Engineering problems related to image production, quality and system design will be examined.

Office hour Time: 3:00-4:00 PM, Tuesdays and Thursdays; other appointments available upon request

Course Grading: 30% - Homework; 30% - Mid-term Exam; 40% - Final Exam.

Approximate grade scale:

A+,	95-100	B+,	80-84.9	C+,	65-69.9	D+,	50-54.9		
A,	90-94.9	B,	75-79.9	C,	60-64.9	D,	45-49.9	F,	0-39.9
A-,	85-89.9	B-,	70-74.9	C-,	55-59.9	D-,	40-44.9		

Reference Material: Lecture slides, select literature, Recommended: Fundamentals of Biomedical Ultrasound by Richard Cobbold

Pre-Requisites: ECE 329 or consent of instructor

Syllabus: (topics covered- corresponding chapters in textbook)
Acoustic wave propagation – Chapter 1: 1.1-1.5
Attenuation in ultrasound – Chapter 1: 1.8
Intensity, impedance, reflection, transmission, scattering, diffraction – Chapter 1: 1.5-1.8
Ultrasonic Sources – Chapter 6: 6.1; 6.10
Fields – Chapters 2 and 3: 2.2-2.3; 3.1-3.8
Anatomical Imaging:
- Conventional ultrasonic imaging – Chapter 8: 8.1-8.3
- Arrays – Chapter 7: 7.1-7.3
- Ultrasound Contrast Agents – Chapter 8: 8.6
- Harmonic Imaging – Chapter 8: 8.6

Functional Imaging:
- Doppler (theory) – Chapter 9: 9.1-9.3
- Continuous wave Doppler – Chapter 9: 9.4-9.7
- Pulsed wave Doppler – Chapter 10: 10.1-10.5
- Color Flow Imaging – Chapter 10: 10.7-10.8; 10.10

Advanced ultrasonic imaging:
- Coded excitation – Chapter 8: 8.4
- Elasticity imaging – Chapter 8: 8.8
- Plane Wave Imaging and synthetic aperture imaging – Chapter 8: 8.5
- 3D Ultrasound imaging – Chapter 7: 7.3

Class schedule:

Tue	**Thu**
Jan 16 L1: Intro to biomedical ultrasound imaging	**Jan 18** L2: Wave propagation and wave equations
Jan 23 L3: Impedance, intensity, reflection, transmission, refraction, diffraction, and scattering I	**Jan 25** L3: Impedance, intensity, reflection, transmission, refraction, diffraction, and scattering I
Jan 30 L3: Impedance, intensity, reflection, transmission, refraction, diffraction, and scattering II	**Feb 1** L4: Ultrasonic sources I
Feb 6 L4: Ultrasonic sources II	**Feb 8** L4: Ultrasonic sources III
Feb 13 L4: Ultrasonic sources IV	**Feb 15** L5: Field calculation I
Feb 20 L5: Field calculation II	**Feb 22** L6: Conventional US imaging I (A, B, C, and M mode)
Feb 27 L6: Conventional US imaging II (A, B, C, and M mode)	**Feb 29** L7: Ultrasound imaging arrays I
Mar 5 L7: Ultrasound imaging arrays II	**Mar 7** L7: Ultrasound imaging arrays III Mid-term exam (L1-L6)
Mar 12 Spring break	**Mar 14** Spring break
Mar 19 L7: Ultrasound imaging arrays IV	**Mar 21** L7: Ultrasound imaging arrays V
Mar 26 L8: Ultrasound contrast agents I	**Mar 28** L8: Ultrasound contrast agents II
Apr 2 L9: Tissue harmonic imaging I	**Apr 4** L9: Tissue harmonic imaging I
Apr 9 L9: Tissue harmonic imaging II	**Apr 11** L10: Introduction to Doppler
Apr 16 L11: Continuous wave Doppler and pulsed wave Doppler I	**Apr 18** L11: Continuous wave Doppler and pulsed wave Doppler II
Apr 23 L12: Color flow imaging and other methods for extracting flow velocity I	**Apr 25** L12: Color flow imaging and other methods for extracting flow velocity II

Apr 30 L13: Advanced topics	**May 2** Reading day
	May 9 Thursday (7:00-10:00 PM) ECEB 2015 Final Exam (L1 to L12)

Homework: There will be 9 graded homework sets for this course. Homework assignments will be distributed on-line and will be graded with Gradescope. Solutions will be posted on the course website. Late homework will NOT be accepted. Detailed homework assignment schedule and deadline are given in the class schedule. Please register on Gradescope using your real name and your Illinois email account with your netID. The site is FERPA compliant. The entry code to the course on Gradescope is **KK78KR**.

Software: for this course we will use MATLAB for completing some problems in the homework sets. If you have never used MATLAB please contact me on how to acquire and use MATLAB.

Exams: a mid-term exam will be given as noted in the attached class schedule. A final exam will be given 7:00-10:00 PM, Thursday, May 9. All exams will be closed book and closed notes. An excuse from the Dean's office is the only acceptable excuse for missing an exam.

Grade disputes: all grade disputes associated with homework assignments and mid-term exams should be submitted within one week from the returning of your graded homework and exams. No regrading will be allowed for the final exam.

Other statements:

Sexual Misconduct Reporting Obligation
The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX Office. In turn, an individual with the Title IX Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Academic Integrity
The University of Illinois at Urbana-Champaign Student Code should also be considered as a part of this syllabus. Students should pay particular attention to Article 1, Part 4: Academic Integrity. Read the Code at the following URL: http://studentcode.illinois.edu/.

Academic dishonesty may result in a failing grade. Every student is expected to review and abide by the Academic Integrity Policy: https://studentcode.illinois.edu/article1/part4/1-401/. Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity.

Religious Observances
Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements. You should examine this syllabus at the beginning of the semester for potential conflicts between course deadlines and any of your religious observances. If a conflict exists, you should

notify your instructor of the conflict and follow the procedure at https://odos.illinois.edu/community-of-care/resources/students/religious-observances/ to request appropriate accommodations. This should be done in the first two weeks of classes.

Disability-Related Accommodations

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor and the Disability Resources and Educational Services (DRES) as soon as possible. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 333-4603, e-mail disability@illinois.edu or go to https://www.disability.illinois.edu. If you are concerned you have a disability-related condition that is impacting your academic progress, there are academic screening appointments available that can help diagnosis a previously undiagnosed disability. You may access these by visiting the DRES website and selecting "Request an Academic Screening" at the bottom of the page.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See https://registrar.illinois.edu/academic-records/ferpa/ for more information on FERPA.

Anti-Racism and Inclusivity

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to the Bias Assessment and Response Team (BART) (https://bart.illinois.edu/). Based on your report, BART members will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.

Counseling and help:

If you need mental health counseling or help, don't hesitate to contact the Counseling Center (https://www.counselingcenter.illinois.edu) which provides services to address emotional, interpersonal, and academic concerns. The Center also provides emergency service (https://www.counselingcenter.illinois.edu/emergency-0). Another option that you have is to contact the ECE department advising office (Jen Merry, merry@illinois.edu, 217-333-9710), or the advising office in your perspective department if you are not an ECE student. Of course you can always contact me if you have any concerns or need any help.