

Biomedical Ultrasound Imaging

ECE 472

Spring 2022

11:00-12:20, Tuesdays and Thursdays, ECEB 3020

Instructor: Pengfei Song, Ph.D. (Assistant Professor)

Office: Beckman 4041; Phone: (217) 300-9763; e-mail – songp@illinois.edu

Website: <https://courses.engr.illinois.edu/ece472/sp2022/>

Class Zoom link:

<https://illinois.zoom.us/j/89452320996?pwd=OHV0UjdDNFZEdEI0ZDFEcElkQWt1QT09&from=addon>

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, Wednesday and Friday; other appointments available upon request

Office hour zoom link:

<https://illinois.zoom.us/j/81694427573?pwd=czRQQUNBK25lSERsTDlJdXM2R0JvZz09&from=addon>

Course Grading: 30% - Homework; 40% - Mid-term Exams I, II; 30% - 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 18 L1: Intro to biomedical ultrasound imaging	Jan 20 L2: Wave propagation and wave equations
Jan 25 L3: Impedance, intensity, reflection, transmission, refraction, diffraction, and scattering I HW 1 handout	Jan 27 L3: Impedance, intensity, reflection, transmission, refraction, diffraction, and scattering II
Feb 1 L4: Ultrasonic sources I HW 1 due (HW 2 handout)	Feb 3 L4: Ultrasonic sources II
Feb 8 L4: Ultrasonic sources III HW 2 due (HW 3 handout)	Feb 10 L4: Ultrasonic sources IV
Feb 15 L5: Field calculation I HW 3 due (HW 4 handout)	Feb 17 L5: Field calculation II
Feb 22 L6: Conventional US imaging I (A, B, C, and M mode) HW 4 due (HW 5 handout)	Feb 24 Exam I (from L1 to L4)
Mar 1 L6: Conventional US imaging II (A, B, C, and M mode)	Mar 3 L7: Ultrasound imaging arrays I
Mar 8 L7: Ultrasound imaging arrays II HW 5 due (HW 6 handout)	Mar 10 L7: Ultrasound imaging arrays III
Mar 15 Spring break	Mar 17 Spring break
Mar 22 L7: Ultrasound imaging arrays IV HW 6 due (HW 7 handout)	Mar 24 L7: Ultrasound imaging arrays V
Mar 29 L8: Ultrasound contrast agents I HW 7 due (HW 8 handout)	Mar 31 L8: Ultrasound contrast agents II

Apr 5 L9: Tissue harmonic imaging I HW 8 due (HW 9 handout)	Apr 7 Exam II (from L5 to L8)
Apr 12 L9: Tissue harmonic imaging II	Apr 14 L10: Introduction to Doppler
Apr 19 L11: Continuous wave Doppler and pulsed wave Doppler I HW 9 due (HW 10 handout)	Apr 21 L11: Continuous wave Doppler and pulsed wave Doppler II
Apr 26 L12: Color flow imaging and other methods for extracting flow velocity I HW 10 due (HW 11 handout)	Apr 28 L12: Color flow imaging and other methods for extracting flow velocity II
May 3 L13: Advanced topics HW 11 due	May 12 Thursday (8:00-11:00AM) Final Exam (L1 to L12)

Team workspace: you have been added to a group on Microsoft Team. You may post your questions about homework and/or find answers to similar questions asked by other students on Team. I check Team regularly but may not be able to provide responses or answer questions immediately. You are strongly encouraged to use office hours if you want to directly reach out to me for questions.

Homework: There will be 11 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 7436XG.**

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: two mid-term exams will be given in class (during regular class meeting hours) as noted in the attached class schedule. A final exam will be given 8:00-11:00 AM, Thursday, May 12. 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

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.

Observances

Disability-Related

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.

Accommodations

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.