

BME 581: ULTRASOUND IN MEDICINE AND BIOLOGY

Objectives

This course aims to cover the physical principles behind ultrasound and its medical imaging modes. Other uses of ultrasound in the biomedical field are also studied, including flow analysis and therapy. Its overall goal is to equip students with a firm understanding on the key technical principles in ultrasound and its biomedical applications.

Calendar Entry

Ultrasound physics, scanning modes, data acquisition schemes, transducer basics, wave-matter interactions; biomedical applications of ultrasound including imaging, flow measurements, therapy, drug delivery.

Course Prerequisite

BME 386 – Physics of Medical Imaging (or with instructor permission)

Learning Outcomes and Alignment with CEAB Graduate Attributes

By the end of this course, students should be able to demonstrate a threshold level of mastery of the following learning outcomes:

1. Describe how ultrasound is used in diagnostics and therapy
2. Summarize the technical principles related to ultrasound
3. Give examples on the biomedical applications of ultrasound
4. Explain the bioeffects that can be induced by ultrasound and its potential safety concerns
5. Perform experiments with an ultrasound scanner

The following CEAB graduate attributes are associated with each of the learning outcomes:

CEAB Attribute #1: A Knowledge Base for Engineering (aligned with learning outcomes 1, 2, 3, 4)

- Demonstrated competence in university-level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

CEAB Attribute #2: Engineering Analysis (aligned with learning outcome 2)

- An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

CEAB Attribute #3: Investigation (aligned with learning outcome 5)

- An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

CEAB Attribute #5: Use of Engineering Tools (aligned with learning outcome 5)

- An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

CEAB Attribute #8: Professionalism (aligned with learning outcome 4)

- An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.

CEAB Attribute #9: Impact of Engineering on Society and the Environment (aligned with learning outcome 3)

- An ability to analyze social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

Teaching Staff

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Grading Scheme

In-Class Discussions	10%
Imaging Laboratory	25%
Group Trivia Sessions	20%
Group Webinar	15%
Term Assignment	30%

Lecture Topics

Theme 1: Introduction to ultrasound imaging

- Basic ultrasound principles
- Basics of ultrasound imaging
- Ultrasound imaging acquisition and beamforming
- Ultrasound-based blood flow measurements

Theme 2: Ultrasound wave-matter interactions

- General interactions in imaging
- Nonlinear ultrasonics and its imaging applications
- Principles of acoustic cavitation
- Principles of acoustic radiation and streaming

Theme 3: Therapeutic ultrasound

- Thermal-based ultrasound therapy
- Microbubbles in imaging and therapy

Theme 4: Biosafety considerations

- Ultrasound-induced bioeffects
- Ultrasound measurement and protection standards

Learning Resources

Required text / References

Review articles and tutorial papers will be provided by the instructor. No formal textbook is required.

Course website

Selected course material will be posted on LEARN in addition to announcements and important dates/deadlines: students are advised to regularly consult the LEARN site for this course.

General Administrative Policies

UW Policy on Attendance: “Students are expected to attend all scheduled components of the courses in which they have enrolled. Students may be required to present documentation confirming the reasons for non-attendance. During the course add period, students may be removed from a course for non-attendance. Students who are removed from a class will be notified by the Registrar's Office. “
<https://ugradcalendar.uwaterloo.ca/page/Acad-Regs-Class-Attendance>

SYDE-BME Comment on Attendance and Accommodation: We respect that our SYDE-BME students are independent adult decision-makers, with many opportunities to partake in activities that might be in time conflict with academic deadlines and deliverables. Students may self-elect to forgo attending class or deliverables for a variety of personal reasons (e.g. attend a co-op interview, celebration, conference, compete in a non-UW sanctioned event such as a pitch contest or extra-curricular, travel, etc.). Along with the right to make adult decisions comes the responsibility and accountability for those decisions and any outcomes.

The University of Waterloo's policy on accommodation for missed deliverables pertains to verifiable health matters, and highly unfortunate events (e.g. family tragedies). The Department of Systems Design Engineering follows UW's general policy: students who self-elect to be away during class time and/or deliverables receive a "0" for that deliverable. It is preferred practice so that fairness is maintained for members of the same class/course by avoiding preferential treatment, and so that instructors are not burdened with having to create extra quizzes, deliverables, etc. It also reflects professional practice, as failing to show up to work and missing deadlines can be very costly to the company and individual (e.g. not submitting a contract proposal, or design review on time). **Please read the policy here:** <http://ugradcalendar.uwaterloo.ca/page/Acad-Regs-Accommodations>

SYDE-BME Comment on Co-op Interviews and Academic Deliverables: Academic Deliverables are to take priority over co-op interviews. This is especially true for course midterms and final exams. Students who have been scheduled for an interview at the same time as a course test, midterm, or exam, **MUST** follow the CECA procedure for rescheduling the interview: <https://uwaterloo.ca/co-operative-education/find-your-co-op-job/waterloos-co-op-process/interview-process/interview-process-and-procedures>.

Compassionate Accommodation: There are times when the Department will make compassionate accommodation for students experiencing circumstances beyond their control. When warranted, the Associate Chair Undergraduate (ACUG) and Director of BME coordinate a reasonable and fair plan in consultation with appropriate others (e.g. instructors, Department Undergraduate Studies Committee, Chair, AccessAbility Services, Engineering Counselling services, Registrar's Office).

Students: If you are going to be absent, let us know. We can help you interpret policy for your case; and help with coordination of reasonable accommodation if it is appropriate. If you have questions or concerns about accommodation, please speak to or email Dr. Bryan Tripp (Director BME sdbmedir@uwaterloo.ca).