Lincoln University

DI 10 – Physical Principles of Ultrasound

COURSE SYLLABUS

Summer 2019

Instructor: Len Filane, Ph. D. (*)
Lecture Schedule: Tuesday, Thursday, 12:30 PM – 3:15 PM
Credits: 3 units / 45 hours of lectures
Level: Introductory (I)
Office Hours: By appointment e-mail: lfilane@lincolnuca.edu
Textbooks: Diagnostic Ultrasound: Principles and Instruments by Frederick W. Kremkau,
Saunders Publishing, 8th edition (Sonography Principles and Instruments, 2010),
ISBN-10: 143770980X, ISBN-13: 978-1437709803
7th edition (2005), ISBN-10: 0721631924, ISBN-13: 9780721631929

ARDMS Physics Test samples from different sources

Ultrasonography Examination by Odwin & Fleischer,
Lange Review Series – McGraw-Hill, 4th edition (2012) ISBN-10: 007163424X, ISBN-13: 978-0071634243

Ultrasound Physics Review by Davies Publishing (2009) ISBN-10: 0941022749, ISBN-13: 978-0941022743

Prerequisite: SCI 10 or equivalent

Last Revision: June 2, 2019

CATALOG DESCRIPTION

This course introduces ultrasound physical principles and instrumentation. Topics include sound wave mechanics, transducers, ultrasound equipment, Doppler physics, imaging modes, artifacts, quality, bio-effects and safety techniques. Introduction to some leading ultrasound systems and probes and their usage. Prerequisite: SCI 10 or equivalent

EDUCATIONAL OBJECTIVES AND STUDENT LEARNING OUTCOMES

Upon satisfactory completion of this Course, the students will be able to:

1. Describe the characteristics of sound wave.

2. Explain the fundamental requirements for sound to travel.
3. Discuss medium stiffness, density.
4. Explain the difference between pulsed wave and continuous wave.
5. Relate frequency / period, pulse repetition frequency / pulse repetition period.
6. Discuss duty factor, pulse duration, spatial pulse length.
7. Explain different modes of scatterings.
8. Explain the three processes in which attenuation occurs.
9. Explain how attenuation is calculated.
10. Identify elements of an ultrasound transducer. Types of probes.
11. Relate single crystal, arrays, matrix, mechanical/electronic probes.
12. Explain characteristics of a transducer, frequency, crystal thickness, matching layers.
13. Relate frequencies, bandwidth, quality factor.
14. Discuss echogenicity: hyperechoic, hypoechoic, isoechoic.
15. Relate near zone, far zone, focal zone, beam width.
16. Discuss attenuation, penetration. Resolutions, wavelength, line density, frame rate.
17. Relate impedance / reflection, velocity / refraction.
18. Identify different components of an ultrasound system.
19. Discuss transmit power, receiver gain, TGC, dynamic range, pre-processing, postprocessing, persistence.
20. Learn 2D-imaging, 3D-imaging, M-mode, Doppler mode, color flow imaging, contrast imaging, harmonic imaging, PW Doppler, CW Doppler, tissue Doppler imaging, Color M-node.
21. Discuss different types of flows: plug, laminar, parabolic, turbulent, Doppler effects.
22. Discuss artifacts: reverberation, mirror image, comet tail, ring-down, shadow, enhancement, edge shadow, speed error, registration error, section thickness, aliasing. Side lobe / grating lobe.
23. Discuss probe and system quality & reliability, safety, phantom, calibration, maintenance.
24. Discuss ALARA, thermal bio-effect, mechanical bio-effect, cavitation, temperature elevation.
25. Operate ultrasound systems and perform basic scanning.

STUDENT LEARNING OUTCOME ASSESSMENTS

1. Three Quizzes
2. Homework
3. Class Open Discussions
4. Midterm Examination.
5. Final Examination.

The two main objectives of this Course are:

1. Prepare the students for the ARDMS Board Registration Test (120 Questions/2 hours). Actual Test with ARDMS serves as an OBJECTIVE ASSESSMENT of Students Learning Outcomes).
2. Show the students how to properly, effectively utilize ultrasound systems.

COURSE LEARNING OUTCOMES[1]

Course LO	Program LO	Institution LO	Assessment activities
Understand the medical imaging. Analyze technologies designed to introduce energy into tissues. Learn the physics and technology of ultrasound design and the design parameters that determine image contrast, noise, and spatial resolution.	PLO 1, PLO 2	ILO 1a, ILO 2a, ILO 3a	In-class activities, quizzes, midterm and final exams.
Describe the operation of an ultrasound scanner in 2-D and 3-D B-mode, Doppler and color flow mode, and elasticity modes. Choose a transducer type, plug in/activate any transducer, and select the fundamental or harmonic frequency operating range for a given imaging/performance testing task. Describe the role of principle operating controls on a scanner and adjust controls to scan phantoms and test objects.	PLO 2	ILO 1a	In-class activities.

[1] Detailed description of learning outcomes and information about the assessment procedure are available at the Center for Teaching and Learning website (ctl.lincolnuca.edu).

Explain principles underlying ultrasound propagation and biological effects of ultrasound. Have knowledge of clinical uses and limitations/artifacts of ultrasound imaging. Understanding of the technical details of modern medical ultrasound devices and methods to measure acoustic parameters.	PLO 3	ILO 1a, ILO 4a	In-class activities, quizzes, midterm and final exams

INSTRUCTIONAL METHODS

Instructional methods will include lectures by the Instructor and Lab. under his guidance. Classroom activities are collaborative – students should help one another in Class as well as in Lab.

Assignments and projects require students to actively use resources of the library. Detailed guide to business resources of the library as well as the description of Lincoln University approach to information literacy are available at the Center for Teaching and Learning website (ctl.lincolnuca.edu).

ASSESSMENT

Homework	5%
Class participation .	15%
Quizzes	20%
Mid-Term Exam	25%
Final	35%
Maximum total score.	100%

Grading guidelines:
91 to 100% (A-, A), 81 to 90% (B-, B, B+), 71 to 80% (C-, C, C+), 70% (D)

To successfully complete this course, the student should have a total score of 70% or higher.

I do not allow re-takes or make up of the quizzes and exams.

STUDENT LEARNING OUTCOME: Result of the actual ARDMS Physics Test for Certification could be considered as the MOST OBJECTIVE ASSESSMEN of STUDENT LEARNING OUTCOME (SLO).

SCHEDULE

Week 1: Tu Thu	Periodic motion, Transverse and Longitudinal waves, Propagation velocity, Medium, Density. Continuous and pulsed waves, Frequency, Period, Wavelength, Pulsed frequency, duration, period, Duty Factor. **Quizz 1**
Week 2 Tu Thu	 Modes of scattering, refraction, reflection, absorption, attenuation, penetration. Transducers, Probes, Single crystal/array/matrix, Matching layers. **Quizz 2**
Week 3 Tu Thu	 Frequency, Bandwidth, Quality Factor, Echogenicity, Hyperechoic/Hypoechoic/Isoechoic, Near Zone/Focal Zone/Far Zone. Beam width, Depth/PRF/Line Density/Frame Rate, Impedance/Reflection/Velocity/Refraction (Snell's Law)
Week 4 Tu	 Ultrasound Systems and Probes, Transmit Power, Receiver Gain, TGC, Dynamic range, Pre -and Post-Processing, Persistence.

Week 5 Tu Thu	 **Mid-Term Exam** 2-D, 3-D imaging, M-Mode, Doppler Mode, Color Flow Imaging. Spectral Doppler, Contrast Imaging, Harmonic Imaging, PW/CW Doppler, Colo M Mode
Week 6 Tu Thu	 Different types of flows, Plug/Laminar/Parabolic, Disturbed Flows, turbulent, artifacts. Quality, bio-effects, Thermal Index, Mechanical Index, Phantom, Calibration, Maintenance. **Quizz 3**
Week 7 Tu Thu	 Review **Final Exam**

Class Work /Class Participation

Your goal should be to demonstrate the grasp of the concepts, ability to solve problems and critical thinking skills in analyzing them. You should strive to ask relevant questions, volunteer relevant answers, as well as volunteer to solve problems on the board, actively participate in class discussions. Class work is graded on the scale of 0-10.

HOMEWORK

Written HW is graded on the scale 0-10.I will give homework every class, as we move forward. I will collect homework on selected days only. Bring your current homework to every class. Your homework must be stapled, be neat and legible. Avoid submitting "dog ears"! If you write chaotically I would not be able to follow your work, hence I will not be able to grade it. HW that does not meet the above outlined requirements will be rejected and awarded zero points.
Show your work in detail. If you do not show all the work required to complete the homework problems, I will reduce your homework credit. Just showing the answer will not be accepted for any credit.
All homework is to be done by the enrolled student and must be your own work. Any attempt to copy or re-use homework or share the same work between the students will result in zero credit.

No late homework will be accepted. I will not accept any HW after my announcement of the end of the collection process. If you know that you will be absent in class, please email your scanned homework to me prior to the beginning of the current class. If you have a question or an issue regarding your HW, then the best way to resolve it is after class hours.
Do not copy the solutions from the instructor's solution manual or online. If you do it, you will be guilty of plagiarism which is a violation of student conduct code, and may result in you being disciplined, suspended from class or expelled from the school.

UNIVERSITY ATTENDANCE POLICY

Lincoln University uses the class method of teaching, which assumes that each student has something to contribute and something to gain by attending class. It further assumes that there is much more instruction absorbed in the classroom than can be tested on examinations. Therefore, students are expected to attend all regularly scheduled class meetings and should exhibit good faith in this regard.

INSTRUCTOR's ATTENDANCE POLICY

Attendance is mandatory!
I frown on tardiness. If you are frequently late to class, please review your schedule and make the necessary adjustments. Late arrivals are disruptive to class, they adversely affect the performance of all.
If you are late to a quiz or exam you will not be allowed to take it.

UNIVERSITY ACADEMIC INTEGRITY STATEMENT

Students are responsible for proper conduct and integrity in all of their scholastic work. They must follow a professor's instructions when completing tests, homework, and laboratory reports, and must ask for clarification if the instructions are not clear. In general, students should not give or receive aid when taking exams, or exceed the time limitations specified by the professor. In seeking the truth, in learning to think critically, and in preparing for a life of constructive service, honesty is imperative. Honesty in the classroom and in the preparation of papers is therefore expected of all students. Each student has the responsibility to submit work that is uniquely his or her own. All of this work must be done in accordance with established principles of academic integrity.

CLASSROOM ENVIRONMENT

The primary responsibility for managing the classroom environment rests with the faculty. Students who engage in acts that result in disruption of a class may be directed by the faculty member to leave the class for the remainder of the class period. The faculty member should, in the event that such action is necessary, immediately report the incident to the chair of their department, the dean of the school, and the dean of students. Longer suspensions from class, or dismissal on disciplinary grounds, must be preceded by a hearing or administrative conference as set forth in the Code of Student Conduct.

In cases where a student's continued presence in a class, following their initial removal, poses a substantial and immediate threat or disturbance, the vice president of student success or dean of students may suspend the student from attending the class on an interim basis, pending their hearing or administrative conference.

Cell phones are not to be used in the classroom during instructional time. Cell phones that ring and/or are answered during classroom instruction are subject to confiscation by the professor. Confiscated cell phones will be turned over to the dean of students.

POLICY ON ELECTRONIC DEVICES IN CLASSROOM

Students are not allowed to use electronic devices in the classroom or lab at any time. If you have an emergency quietly step outside and take care of it. You can use laptops only if it is directly related to the task at hand. Tape-and video recording without the consent of the instructor is not allowed.

FOOD

Not allowed in the classroom.