Lincoln University

DI 10 – Physical Principles of Ultrasound

COURSE SYLLABUS
Spring 2019

Instructor: Chris T. Nguyen, Ph. D. (*)

Lecture Schedule: Wednesday, 12:30 PM – 3:15 PM

Credits: 3 units / 45 hours of lectures

Level: Introductory (I)

Office Hours: By appointment

e-mail: cnguyen@lincolnuca.edu, or chinguyen39@gmail.com
Home Phone: 510-489-8727
Cell. Phone: 498-439-3448

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: **978-0721631929**

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: January 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, post-processing, 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. Weekly Quizzes (10 minutes, in Class).
2. Home works.
3. Class Open Discussions (Instructor to observe and notice students' outcomes).
4. Q / A Sessions in Class. (Instructor to question and Students to answer).
5. Midterm Examination.

6. Final Examination.

The two main objectives of this Course are:

- 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).

- 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.
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

[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).

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. The Instructor will be available to help students with all tutorials and other assignments.

The Course consists of **15** Lectures, **weekly** Quizzes, Home works, Q/A Sessions, Class Open Discussions, **1** Mid-term, **1** Final and **several Lab.** sessions.
Attendance will be **recorded at every class meeting.**

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).

LECTURE SCHEDULE

Lecture #1 covers items 1, 2 & 3 of SLO: Periodic Motions, Sound Waves, Mechanical and Longitudinal Motions, Propagation Velocity, Medium / Vacuum, Medium Stiffness / Density.
Lecture #2 covers items 3, 4 , 5 and 6 of SLO: Continuous Waves / Pulsed Waves, Frequency / Period / Wavelength, Pulsed Repetition Frequency / Pulsed Repetition Period, Pulse Duration / Spatial Pulse Length, Duty Factor. Quiz on Lecture #1.
Lecture #3 covers items 7, 8 & 9 of SLO: Different modes of Scatterings, Reflections / Refractions / Absorptions, Attenuations / Penetrations, Attenuation Coefficient, Quiz on Lecture #2.
Lecture #4 covers items 10, 11 & 12 of SLO: Transducers / Crystals, Types of Probes, Single Crystal / Array / Matrix, Crystal Thickness, Matching Layers. Quiz on Lecture #3
Lecture #5 covers items13, 14 & 15 of SLO: Frequencies / Bandwidth / Quality Factor, Echogenicity, Hyperechoic / Hypoechoic / Isoechoic, Near Zone / Focal Zone / Far Zone, Beam Width. Quiz on Lecture #4
Lecture #6 covers items 16 & 17 of SLO: Depth / PRF / Line Density / Frame Rate, Impedance / Reflection, Velocity / Refraction (Snell's Law). Quiz on Lecture #5
Lecture #7 reviews items 1 to 17 of SLO to prepare for Mid-term. Quiz on Lecture #7
Lecture #8: MID-TERM. Lecture on item 18: Identify different Ultrasound Systems and Probes.
Lecture #9 covers items 19 &20 of SLO: Transmit Power, Receiver Gain, TGC, Dynamic Range, Pre-processing, Post-processing, Persistence. Quiz on Lecture #8
Lecture #10 covers items 21 & 22 of the SLO: 2D, 3D and 4D Imagings, M Mode, Doppler Mode, Color Flow Imaging, Spectral Doppler, Contrast Imaging, Harmonic Imaging, PW / CW Doppler, Color M Mode. Quiz on Lecture #9
Lecture #11 covers items 23 of the SLO: Different types of Flows, Plug / Laminar / Parabolic, Disturbed Flows, Turbulent, Artifacts, Quiz on Lecture 10
Lecture #12 covers item 24 of the SLO: Quality, Bio-Effects, Thermal Index, Mechanical Index, Phantom, Calibration, Maintenance. Quiz on Lecture #11
Lecture #13 reviews all items from 1 to 24, introduces 900+ ARDMS Physics Test Questions
Lecture #14 reviews all items from 1 to 24, introduces answers to 900+ ARDMS Physics Test Questions
Lecture #15: FINAL EXAM. In the last lesson, we talk about duty, function, attitude, accuracy, quality, responsibility and moral character of a conscientious Sonographer.

EVALUATION

is based on

- Attendance
- Quizzes
- Q / A Sessions in Class
- Class Open Discussions
- Mid-term exam and Final exam
- Lab participation and performance

Grading Scale:

Class attendance and Lab.	10%
Q/A Sessions, Open Disc.	10%
Quizzes and Home works	20%
Mid-Term Exam	20%
Final	40%
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 attend more than 80% of the Lectures, and have a total score of 70% or higher.

(*) **AFFILIATIONS**

- Reviewer Board Member of the Journal "Ultrasound in Medicine", American Institute of Ultrasound in Medicine, since 2010
- Reviewer Board Member of the Journal "Ultrasound in Medicine and Biology", World Federation of Ultrasound in Medicine and Biology, since 2006
- Advisory Editorial Board Member of the Journal "Ultrasound in Medicine and Biology", World Federation of Ultrasound in Medicine and Biology, since 2012

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).