Jordan University of Science and Technology
Faculty of Engineering
Biomedical Engineering Department

BME 563: Diagnostic and Therapeutic Ultrasound

Course Catalog
3 Credit hours (3 h lectures). covers the fundamentals of acoustic propagation, the plane wave and the specific acoustic impedance, how the ultrasound wave propagates between two different mediums in both normal and oblique cases, the reflection and transmission coefficients, the Doppler Effect, the circular piston and its nearfield and farfield approximations, the piezoelectric effect, the electrical tuning matching circuit for a certain ultrasound transducer, the axial and lateral resolutions, the different types of ultrasound arrays, the pulse-echo methods, the biological effects of ultrasound, the wave distortion, and the design of a complete ultrasound transducer for either medical imaging ultrasound or therapeutic ultrasound.

Textbook		
Title	Discrete-time Signal Processing	Diagnostic Ultrasound, Imaging and Blood Measurements
Author(s)	Oppenheim A. and Schafer R.	K. Kirk Shung
Publisher	Prentice Hall	Taylor and Francis
Year	1999	2006
Edition	2nd	

References	
Books	Principles of Medical Imaging, Shung K. K., Smith M. B., and Tsui B., Academic Press, ISBN 0-12-640970-6
Journals	• The Journal of the Acoustical Society of America (JASA) • Ultrasound in Medicine and Biology (UMB) • IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control (IEEE - UFFC)
Internet links	• http://scitation.aip.org/jasa/ • http://www.elsevier.com/wps/ • http://www.ieee-uffc.org/

Instructor	
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Office hours
To be determined

Teaching assistant
To be determined

Pre-requisites	
Pre-requisites by topic	**Biomedical Instrumentation I**
Pre-requisites by course	BME 412
Co-requisites by course	NA
Pre-requisites for	NA

Objectives	Outcomes
1. Understand the fundamentals of acoustic propagation **(1)**	1.1 Being able to define the term "Acoustics". 1.2 Being able to define the term "sound wave". 1.3 Being able to define how the acoustic wave propagates. 1.4 Being able to define how the sound wave is generated.
2. Understand the terms and parameters used in ultrasound **(1)**	2.1 Being able to define the term "pressure". 2.2 Being able to define the term intensity and how it relates to pressure. 2.3 Being able to define the term "particle displacement". 2.4 Being able to define the terms "particle velocity" and "density".
3. Understand and distinguish the various equations used in acoustics **(1)**	3.1 Being able to use the exact continuity equation. 3.2 Being able to use the linear continuity equation. 3.3 Being able to use the wave equation. 3.4 Being able to use Euler's equation.
4. Understand the plane wave and the specific acoustic impedance **(1)**	4.1 Being able to define the term "plane wave". 4.2 Being able to distinguish the characteristics of the plane wave. 4.3 Being able to define the term "specific acoustic impedance". 4.4 Being able to identify the physical meaning of the specific acoustic impedance. 4.5 Being able to define the parameters affecting the specific acoustic impedance. 4.6 Being able to evaluate the specific acoustic impedance. 4.7 Being able to distinguish between the electrical impedance and the specific acoustic impedance.
5. Understand how the ultrasound wave propagates between two different mediums in both normal and oblique cases **(1)**	5.1 Being able to distinguish the various parameters that affect the transmission of ultrasound wave from one medium to another. 5.2 Being able to identify how the amount of transmitted power from one medium to another is affected by the change in acoustic impedance between the two mediums. 5.3 Being able to analyze both normal and oblique transmission cases.
6. Understand the reflection and transmission coefficients **(1, 8, 9)**	6.1 Being able to evaluate the acoustic impedance for a certain medium. 6.2 Being able to evaluate the pressure and intensity transmission coefficient in normal incidence case. 6.3 Being able to evaluate the pressure and intensity reflection coefficient in normal incidence case. 6.4 Being able to evaluate the pressure and intensity transmission coefficient in oblique incidence case. 6.5 Being able to evaluate the pressure and intensity reflection coefficient in oblique incidence case. 6.6 Being able to identify the relationship between the pressure and intensity reflection and transmission coefficients.
7. Understand some important phenomena that occur at the boundaries of different	7.1 Being able to define the term scattering. 7.2 Being able to define the term absorption. 7.3 Being able to define the term reflection. 7.4 Being able to define the term attenuation. 7.5 Being able to define how the ultrasound pressure attenuates as a function of

mediums **(1, 8, 9)**	distance. 7.6 Being able to define how the ultrasound intensity attenuates as a function of distance.
8. Understand the Doppler Effect **(1, 8, 9)**	8.1 Being able to deal with the case where the object is moving away from the source. 8.2 Being able to deal with the case where the object is moving toward the source. 8.3 Being able to define the term "Doppler shift". 8.4 Being able to identify what cause the Doppler shift. 8.5 Being able to define the effect of Doppler shift on Ultrasound imaging.
9. Understand the circular piston and its nearfield and farfield approximations **(1, 2, 6, 8, 9)**	9.1 Being able to define the circular piston. 9.2 Being able to identify what purpose the circular piston is used for. 9.3 Being able to define the importance of the circular piston on ultrasound imaging. 9.4 Being able to define the terms nearfield and farfield. 9.5 Being able to identify the importance of the farfield region on ultrasound imaging. 9.6 Being able to define why the nearfield region must be outside the target area to be imaged.
10. Understand the piezoelectric effect **(1, 2, 6)**	10.1 Being able to define the term "piezoelectric effect". 10.2 Being able to define the electrical / mechanical relationship. 10.3 Being able to identify the reciprocity in the piezoelectric effect.
11. Being able to evaluate the electrical tuning matching circuit for a certain ultrasound transducer **(1, 2, 6)**	11.1 Being able to define what purpose the electrical tuning matching circuit is used for. 11.2 Being able to define what components the electrical tuning matching circuit contains. 11.3 Being able to evaluate the electrical tuning matching circuit. 11.4 Being able to design and test an electrical tuning matching circuit for a certain ultrasound transducer.
12. Understand the axial and lateral resolutions **(2, 6)**	12.1 Being able to define the general term "Resolution". 12.2 Being able to define the specific terms "Axial Resolution" and "Lateral resolution". 12.3 Being able to define what factors affect the axial and lateral resolutions. 12.4 Being able to design a certain transducer with specified axial and lateral resolutions.
13. Understand the different types of ultrasound arrays **(2, 6)**	13.1 Become familiar with the array shapes 1-D, 1.25-D, 1.75-D, and 2D 13.2 Know the differences among these array shapes. 13.3 Know the applications these array shapes are used for. 13.4 Know the advantages and disadvantages of each one of these array shapes.
14. Understand the pulse-echo methods **(1, 2, 6)**	14.1 Being able to define the term pulse-echo. 14.2 Being able to deal with the A-mode system. 14.3 Being able to deal with the B-mode system. 14.4 Being able to deal with the M-mode system. 14.5 Being able to define the relationship between the A-mode and the B-mode. 14.6 Being able to distinguish images generated from different modes
15. Understand the biological effects of ultrasound and the wave distortion **(4, 8, 9)**	15.1 Know what biological effect the ultrasound wave has on normal tissue. 15.2 Know how reduce these affects. 15.3 Being able to define the regulations regarding the safe limits of ultrasound intensities. 15.4 Being able to define the term "wave distortion". 15.5 Being able to identify the effect of wave distortion on Bandwidth
16. Being able to design a complete	16.1 Know how to select the PZT material. 16.2 Know how to design the matching and backing layers.

ultrasound transducer for a certain purpose **(2, 4, 6)**	16.3 Know how to design the electrical tuning for a certain design. 16.4 Know how to design a complete transducer for a certain purpose 16.5 Know how to evaluate a certain design.

Topics covered		
Week	**Topics**	**Chapters in textbook**
1-2	Introduction and fundamentals of acoustic propagation	Chapter 1 (Shung)
3	The acoustic wave equation and simple solutions	Chapter 5 (Kinsler)
4-5	Reflection and transmission of ultrasound	Chapter 6 (Kinsler)
6-7	Attenuation phenomenon, Doppler Effect	Chapter 2 (Shung)
8-9	Radiation from a circular piston	Chapter 7 (Kinsler)
10	Electrical tuning of ultrasound transducers	Chapter 2 (Shung)
11	Axial and Lateral resolutions	Chapter 2 (Shung)
12	Ultrasound arrays	Chapter 3(Shung)
13-14	Grey scale ultrasonic imaging	Chapter 4 (Shung)
15	Biological Effects of ultrasound	Chapter 10 (Shung)

Evaluation		
Assessment tool	**Date**	**Weight**
First exam	According to the university examination schedule	30%
Second exam	According to the university examination schedule	30%
Final exam	According to the university examination schedule	40%

Contribution of Course to Meeting the Professional Component								
Outcomes (%)								
1	2	3	4	5	6	7	8	9
45			5		10		20	20

Relationship to Biomedical Engineering Program Objectives

PEO1	PEO2	PEO3	PEO 4
√	√	√	√

Prepared by: Dr. Khaldon Lweesy
Last modified: October 14th, 2019