BME 599- Ultrasound Physics & Bioinstrumentation
Detailed Learning Objectives

- Below are detailed objectives associated with each topic that we will cover. Topics are linked to chapters in the textbooks, Book 1, "*Ultrasound physics and instrumentation*", by Hedricks, Hykes, Starchman (fourth edition, Elsevier Mosby, Press, 2005), and Book 2, "*Ultrasonic Bioinstrumentation*", by , Douglas A. Christensen. *n*, John Wiley & Sons Inc., 1988. The number of classes shown is approximate.
- Students will know and understand the physical concept in design of US bioinstrumentation, implement these concepts in one of the projects design

Introduction – Chapter 1, Book 1-2 (1 class)

1. The general concepts of waves and its interaction with tissues
2. Advantages and disadvantages of Ultrasound imaging with other methods (XRAYS, CT, MRI, PET, SPECT)

Impedance, Power, and Reflection - Chapter 1-B1, Chapter 3-B2, all sections (2 classes)

1. Definitions of medium impedance
2. Basic definitions for power density
3. Reflection and transmission of waves at interfaces with numerical examples
4. Effect of angle, magnitude and powers of reflected and transmitted waves

Acoustical Properties of Biological Tissues - Chapter 4-B2, Chapter 22-B1 (2 classes)

1. Interaction of waves with matter
2. Effects on cells
3. Effects of Biomolecules
4. Effects on tissues
5. AIUM standards for Bioeffects
6. Attenuation in tissues
7. Viscosity relaxation in tissues
8. Values of Acoustic parameters for biological tissues

Transducers, Beam Patterns and Resolution - Chapter 5-B2, Chapter 4,5B1, all sections (4 class)

1. Electrical excitation of piezoelectric transducer
2. Continuous versus pulsed wave excitations
3. Transducers factors, spatial pulse length, transmission and focusing
4. Beam patterns for Near and Far fields for both circular and rectangular single element transducers
5. Width of beam in Near and Far fields
6. Focusing of beam with lenses and the definition of axial and lateral resolutions
7. Linear arrays

Diagnostic imaging configurations - Chapter 6B2, Chapter 6-9, 17 B1, all sections (7 classes)

1. Static imaging principles and instrumentation of A-Mode Scanning
2. Static B-mode Scanning (Compound B-Scanner)
3. Realtime B-scanners, mechanical and electronic scanners
4. Image formation in real time, scan conversions, beam width, lateral resolution.
5. Electronic focusing, Curvilinear arrays, Linear Phased arrays, annular phased arrays

6. Beam formers and acquisitions
7. Tissue harmonic and compound average imaging
8. High frequency imaging
9. 3D-4D imaging,
10. Elasticity imaging
11. M-mode scanning and operations

Image quality measures and image artifacts - Chapter 11-12 B1 (2)

1. Axial resolution
2. Lateral resolution
3. Contrast resolution
4. Noise
5. Artifacts
6. Geometric distortion
7. Tissue characterization
8. Real-time system design
9. Resonance
10. Side lobes
11. Ghost image
12. Velocity errors
13. Environmental interfaces

Hemodynamics, Doppler and flowmeters - Chapter 13-16 B1, Chapter 7 B2 (5 classes)

1. Hemodynamics, velocity profile
2. Pressure/Flow relations
3. Bernoulli principle
4. Arterial and venous hemodynamics
5. Peak velocity, Eddy flow, Turbulence, Obstruction
6. Doppler principles
7. Continuous wave Doppler
8. Pulsed wave Doppler
9. Doppler spectral analysis
10. Color Doppler imaging

Clinical safety and quality control measures - Chapter 23-25B1, Chapter 8 B2 (3 classes)

1. Possible mechanism of damage
2. Thermal effects, cavitations, and considerations
3. Obstetrics considerations
4. AIUM model to limit fetal temperature risk
5. Measuring US exposure levels
6. Phantoms
7. Measurements accuracies