BME 4400 Fall 2022
Assignment #6
Due:November 27, 2022 9:00 PM

1. Given a 4 MHz ultrasound system, you transmit a pulse of amplitude A0 into skeletal muscle and then detect an echo 55 µs later. The amplitude of the echo is 60.5 dB lower than A0, do you think the echo came from an intramuscular lipoma (fatty tumor) or watery cyst?

tissue	c (m/s)	Z (kg m^{-2} s^{-1} x 10^6)	α_0 (dB cm^{-1} MHz^{-1})
fat	1450	1.35	0.63
muscle	1540	1.7	1.1
bone	4080	5	20
Water	1500	1.48	0.02

2. Using a 2 MHz CW doppler setup, you measure a doppler frequency shift of -1000 Hz. What is the velocity and direction (relative to the US pulse path) of the blood flow?

beam geometry

find max depth?

3. Assuming a wave propagation velocity of 1540 m/s, attenuation coefficient α_0 = 0.9 dB/cm/MHz, the ability to detect a pressure signal attenuated by 100 dB, and a single 20 mm diameter transducer, what operating frequency will provide optimal lateral resolution at a distance = 1/2 the max depth of view? (assume the primary tissue boundary of interest reflects a pressure wave of ≈1% amplitude.)

4. The attached file, carotid.mat, contains raw ultrasound channel data of a carotid artery. Note that this is not truly "raw" since it has already been delayed and summed as needed for a phase array transducer. There are several steps remaining before the picture becomes informative. There are three data objects: 'rfdata' is a 2D matrix, with A-mode data down each column and 256 columns, 'axial' is a vector of the depth at each time point (units of meters), and 'lateral' is a vector of the distance across the aperture (units of meters).

   a. First, extract the envelop from each column of A-mode data. You can do this with abs(hilbert(rfdata)), but you must also compute this with your own code using the mathematical description presented in class. For a single column of data, plot the A-mode data, the envelope extracted with your own code, and the envelope extracted with the 'hilbert' function (which should match your result).

   b. Use the envelope data from all columns to generated a 2D grayscale

   c. Hopefully you noted the large range of intensity values in your previous images. Now it's time to log compress and scale the image for better visualization. Comment on what you see.

   d. Finally, log-compress the data to convert the intensities to dB (note that you're starting with amplitude, not power quantities). Adjust the quantities such that the maximum intensity is 0 dB, then present the image on a -60dB to 0dB grayscale. (You can use 'imagesc(…, [-60 0])')