# Diagnostic Ultrasound Imaging: Inside Out by T. L. Szabo
## Problem Set 7 for Chapter 8

1. The backscatter (at 180 degrees) of a fat globule sphere of radius a= 0.1 mm, suspended in water, is measured by three transducers with the following characteristics: radius 1 mm, center frequency $f_c$ = 50 MHz; radius 10 cm, center frequency $f_c$ = 0.25 MHz; radius 1 cm, and center frequency $f_c$ = 2.5 MHz. Use the parameters from the materials table in Appendix B for fat and water at 20 deg. C and find the ratio of backscattered intensities relative to the incident values. Assume the effects of focusing and pulse shape are negligible and that the effective compressibility can be found from the speed of sound.
2. An inventor thought of using ultrasound for encryption by reading letters hidden in solids with an ultrasound beam. He developed a patented process by which he could modify the scattering strength of small rigid spheres imbedded in a host material. To try out his idea, he calculated the acoustic scattering weight of each sphere placed in a circular arc at a distance r from the center of a line aperture having a length of 50 wavelengths. The spheres were each separated by an angle of $10^{-4}$ degrees. He assumed that the pulse length was long and that r was equal to the transducer focal length. He chose the weights of 13 spheres to display a "W" letter when illuminated by a beam from the line aperture. He determined the relative weighting of each sphere, $s_n$, based on the assumption that the fixed beam was steered straight ahead and that only one sphere at a time returned a backscattered signal. He designed the weights so that each backscattered signal had an amplitude corresponding to one of the amplitudes of a "W." The letter "W" has the following amplitudes when written as a MATLAB vector: w=[1.0 0.75 0.5 0.25 0.0 0.25 0.50 0.25 0.0 0.25 0.5 0.75 1.0]

(a) Find the relative weights for each sphere according to the inventor's plan assuming that an end sphere will have a relative backscatter weight of 1 after reception. If you use a MATLAB program, please include it.

(b) The inventor, thought that determining the weights individually for an unsteered beam as in part a would be the same as the backscatter signals from the same fixed pattern of weighted spheres with the transducer line aperture rotated through an arc that scanned past the spheres. The inventor measured the actual backscatter amplitudes after weighting each sphere according to his plan and rotating the transducer to each sphere position in an arc. He did not measure what he expected. Why didn't his approach work? Is there a way to make his original idea work? If so, describe how without actually solving the problem numerically.