Homework 3: Answer Key

1) Under a gradient, resonant frequency is linearly related to to position

$f(x) = Gx$

where f means frequency, x means position, and G is the gradient strength. We want to solve for thickness, or Δx (the range of tissues that absorbs the range of frequencies in our pulse). If $\Delta f = G*\Delta x$, then $\Delta x = \Delta f/G$.

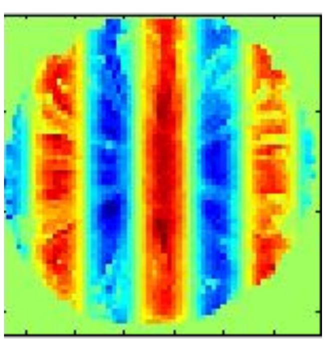
The only problem there is that bandwidth is in Hz and the gradient is given to us in units of field/distance, so the dimensions won't work out until we change the gradient to units of frequency per distance, so first we convert the gradient using the gyromagnetic ratio: $G = 2$ G/cm * 42.58 MHz/T = 2 *10^{-4} T/cm * 42.58*10^{6} Hz/T = 2 * 42.58 * 10^{-4}*10^{6} T/cm Hz/T = 8,516 Hz/cm. So the frequency changes by 8,500 Hz every time you move 1 centimeter. So a 1700 Hz bandwidth will interact with 1700/8500 = 0.2 cm or 2 mm of tissue.

Figuring out slice location follows the same logic. If the field is changing at a rate of 4,258 Hz/cm (third line of the table), a carrier (center) frequency that is 17,032 different from my isocenter reference will move my slice 4 cm away from isocenter … under a y gradient with a positive frequency offset, I'll find my slice 4 cm superior to isocenter.

gradient orientation	gradient strength	pulse carrier frequency	pulse bandwidth	slice orientation	slice location	slice thickness
x	20 mT/m	123.482000 MHz	2555 Hz	**sagittal**	**isocenter**	3 mm
y	2 G/cm	123.499032 MHz	1700 Hz	**coronal**	2 cm A	**2 mm**
z	10 mT/m	123.499032 MHz	1700 Hz	axial	**4 cm S**	**4 mm**

2) Which of the above parameters needs to change if you do the experiment at 7T instead of 3T? **Just the carrier frequencie**s.

3) The echo forms when all of the spin isochromats everywhere in the pineapple slice are pointing the same direction (in phase). That's the only time we get a really big signal. In the illustrations I'm using, really, the echo should be green everywhere … so the illustration below is more accurate than in the homework as assigned.



4) K-space is the 2D Fourier transform of the image. We're still building intuition for for why this is true, but lower spatial frequencies are at the center of k-space, so the image on the right is closer to the center of k-space.