Homework 3: Answer Key

1) Under a gradient, resonant frequency is linearly related to to position, i.e., f(x) = Gx, where f means frequency, x means position, and G is the gradient strength. Slice thickness is Δx … the range of positions where you'll find spin isochromats that resonate with one of the frequencies in the pulse bandwidth, Δf. We want to solve for thickness. If Δf = G*Δx, then Δx = Δf/G … we're going to divide the pulse bandwidth by the gradient to get the thickness.

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. Finally … thk = BW/G = 1700 Hz / 8,516 H/cm = 0.2 cm or 2 mm

Figuring out slice location follows the same logic. If the field is changing at a rate of 4,258 Hz/cm, 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) To figure out the frequencies in the different locations, you use the same logic as above, e.g., 30 mT/m = 12,774 Hz/cm, so the frequency 9.6 cm from isocenter is 12,774*9.6 = 122,630 Hz away from the reference frequency at isocenter (no knowledge of isocenter frequency needed). To figure out the relative phase at a given time, just multiply the frequency (cycles/sec) * time (sec) to get a number of cycles, and then ignore the whole-number part of the answer, e.g., 122,630 cyc/sec * 0.01 sec = 1,226.3 cycles, so phase is 0.3 cyc or 0.6π.

axis	strength	f, 9.6 cm R of center	f, 9.6 cm L of center	f, 9.6 cm A to center	f, 9.6 cm P to center	f, 9.6 cm S to center	f, 9.6 cm I to isocenter	ϕ, 9.6 cm R, at 100 μsec	ϕ, 9.6 cm S, at 10 ms
x	15 mT/m	**61,315 Hz**	**-61,315 Hz**	0 Hz	0 Hz	**0 Hz**	**0 Hz**	0.13 cyc or 0.26π	**0**
z	30 mT/m	0 Hz	0 Hz	**0 Hz**	**0 Hz**	**122.63 kHz**	-122.63 kHz	0	**0.3 cyc or 0.6π**

4) Do any of the above parameters change if you change the field strength of the experiment? **Nope**