1. **Understanding the basic spin echo imaging sequence.**
   a. Place a large phantom in a birdcage coil and position in scanner. Scan the phantom using a spin echo pulse sequence with $x_{res}=256$, $y_{res}=128$, $r_{hexecctrl}=11$ to save raw data. Record the values of the CV $area_{gz1}$, the area of the slice rephaser in G/cm-us. Calculate and set the required reduction in $area_{gz1}$ in order to generate a phase shift of $\pi$ across the width of your slice. Scan again. Verify the reduction in the area of $gz1$ using the oscilloscope. Further reduce $area_{gz1}$ to generate a phase shift of $2\pi$ across your slice. Scan again.
   i. From the first image, calculate what the intensity of your second image would be if the slice profile was a perfect rect function. Generate an image of the difference between this ideal calculated second image and your actual second image. Repeat for the third image. (5 points)
   b. Return $area_{gz1}$ to it’s default value. Record the value of CVs: $a_{gx1}$, $pw_{gx1}$, $pw_{gx1a}$, and $pw_{gx1d}$. These are the amplitude and pulse widths of the readout dephaser gradient, with the a and d suffixes denoting the attack and decay of the trapezoidal gradient. Repeat the scan with the value of $a_{gx1}$ reduced by a factor of 2. Generate images of the magnitude of the raw data before FT for both data sets. Generate images of both the magnitude and phase of the images after FT.
   i. Why is the echo located in K-space where it is in the two scans. Write a mathematical expression for the location of the echo as a function of $a_{gx1}$. Note whether your expression is in absolute units of k (ie cm$^{-1}$) or pixel units in k-space. (3 points)
   ii. Why are the phases of the images different? Write a mathematical expression that describes the relative phases of the two images as a function of the position $x$ along the frequency encode direction and the changes in the area of $gx1$. State what the units of your expression are (ie if there is a phase slope, is it in rad/cm, or rotations per pixel, or ???) (3 points)

2. **Calculate proton density, $T_1$, and $T_2$ maps from spin echo data.** Place a large phantom with some structure (ie not a simple sphere or cylinder, food is good) in a volume coil. Collect spin echo images at 5 values of TE for a fixed TR, and 5 values of TR for a fixed TE. From the images:
   a. Calculate a map of the relative proton density (times RF sensitivity) of the phantom. (3 points)
   b. Calculate a map of the $T_1$ of the phantom. (3 points)
   c. Calculate a map of the $T_2$ of the phantom. (3 points)