**CISC 472 Assignment 2**

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**Q1** [1 mark] How long should a transverse B1 field of 2 μT (microTesla) be turned on to effect a 90 degree tilt in the 1H proton magnetic moments? Be careful with your units. Show your work.

**Q2** [2 marks] Plot the T1 recovery of Mz for muscle and liver. Plot the T2 relaxation of Mxy for muscle and liver. Calculate the best TR for maximum contrast in a T1-weighted image. Show your work. Show your calculated TR on your T1 graph.

**Q3** [1 mark] Using inversion recovery, what TI should be used to make muscle tissue appear completely black on the MRI image? Show your work.

**Q4a** [1 mark] The notes state that the magnitude of the wavevector, kk, is *proportional* to the magnitude of the gradient integral. What is the constant of proportionality? Explain briefly.

**Q4b** [1 mark] Given your answer for 4a, what is the value of the gradient integral required to sample at wavevector k=(3,4) and what are its units?

**Q5** [1 mark] Since the aggregate moment vector is precessing in the MHz range, its *phase* is changing very, very fast. When sampling (i.e. reading) the moment vector, slightly different sampling times will have much different phases. Explain why the time that a sample is made is *not* critical in determining the phase of the sinusoid corresponding to wavevector k.

**Q6** [2 marks] The phase-encoding method fills samples in the frequency domain, then applies an inverse Fourier Transform. The filtered backprojection method uses frequency encoding and projections to build an "MRI sinogram" and then applies filtered backprojection. Phase-encoding has long supplanted filtered backprojection to reconstruct MRI images. Explain with reference to the kk-space why phase-encoding is better.

**Q7** [1 mark] For an n×n image, describe the appearance of the highest-frequency sinogram in the xx direction in the spatial domain. Explain why it appears like this.

**Q8** [2 marks] Assuming a maximum gradient of 40 mT/m (milliTesla/meter) and a 60cm x 60cm transverse slice, what is the shortest time it would takes to move the wavevector kk from the origin to a corner of the 512×512 frequency domain? Show your work and explain what you did. (Note that all gradients are zero at the isocentre.)

**Q9a** [4 marks] Develop mathematical gradient functions, Gx(t) and Gy(t), for a *smooth* spiral traversal of the frequency domain, starting with a wavevector k=(0,0) and rotating k counterclockwise such that the magnitude of kk increases by one with each rotation. The rate of traversal (i.e. the magnitude of the corresponding ∣∣dk(t)dt∣∣ must be *constant*. Be careful not to mix up Gx(t) and Gy(t), which are both gradients as a function of time. Show your work and explain your derivation. Plot graphs of Gx(t) and Gy(t).

**Q9b** [1 mark] After sampling the amplitude and phase shift (and converting them to complex coefficients, ck) at regular intervals on your spiral traversal of 9a, what additional step must be done before applying the inverse Fourier transform to get the spatial image?