1. Consider the state $\left|\psi\right\rangle = \frac{1}{\sqrt{2}}(\left|00\right\rangle + \left|10\right\rangle)$. What is the state that results from applying the 2-qubit Hadamard transform to $\left|\psi\right\rangle$?

   Now regard ψ as a superposition over numbers modulo 4 (i.e. it is a superposition of 0 and 2 written in binary notation). What is the state that results from applying the Fourier transform modulo 4 to ψ?

   Finally, consider the state $\left|\psi\right\rangle = \frac{1}{\sqrt{2}}(\left|00\right\rangle + \left|01\right\rangle)$. Regard it as a superposition over numbers modulo 4. What is the Fourier transform modulo 4 of this state? Anything surprising about the difference between this and the previous answer?

2. Consider a superposition on n bit strings $\left|\psi\right\rangle = \frac{1}{\sqrt{M}}\sum_{x:u\cdot x=0}\left|x\right\rangle$ where the sum is over all n bit strings x such that $u\cdot x = 0$. Here u is a fixed non-zero n bit string and $u\cdot x = u_1x_1 + u_2x_2\ldots u_nx_n (mod\ 2)$. What is M?

   Apply the n-qubit Hadamard transform to $\left|\psi\right\rangle$ and let the result be $\left|\phi\right\rangle = \sum_x \alpha_x\left|x\right\rangle$. What is $\alpha_{00\ldots0}$?

   What is $\left|\phi\right\rangle$

3. *Convolution-Multiplication*. Suppose we shift a superposition $\left|\phi\right\rangle = \sum_{j=0}^{M-1}\alpha_j\left|j\right\rangle$ by l to get the superposition $\left|\phi'\right\rangle = \sum_{j=0}^{M-1}\alpha_j\left|j+l\right\rangle$ (by $j+l$ we mean modulo M). How does this change the QFT of $\left|\phi\right\rangle$?