Midterm review

1. What is the final state after applying the following rotations to the following states:

a) $R_Y(\pi/2)|0\rangle = ?$

b) $R_z(\pi/2)|\text{-i}\rangle = ?$

c) $R_X(-\pi/2)\,|1\,\rangle = ?$

d) $R_Y(-\pi/2)\;R_Z(\pi)\,R_Y(-\pi/2)\,|1\,\rangle = ?$

e) $R_Y(-\pi/2)\cdot R_Z(\pi/4)\cdot R_Y(\pi)\cdot R_Z(\pi/4)\cdot R_Y(-\pi/2)\,|1\,\rangle = ?$

2. Check to see if the two states |+i⟩ and |-i⟩ are orthogonal. Show your work.

3. If you measure the state $e^{i\pi/4}[\frac{|+i\rangle - i|-i\rangle}{\sqrt{2}}]$ in the X basis, what do you get?

4. Write out a state that when measured is 1/9 |0⟩ and $8/9$ |1⟩
(as percentages after measurement: $11\%|0\rangle$ and 89% |1⟩)

5. Write out the same state as above but with a relative phase of $\pi/4$

6. If you have the following Stern Gerlach apparatus, how many qubits make it through?

- **a)** Z quantization then polarization to $|0\rangle_Z$
- **b)** Y quantization then polarization to $|-i\rangle_Y$
- **c)** X quantization then polarization to $|+\rangle_X$
- **d)** Y quantization then polarization to $|-i\rangle_Y$

7. In a few sentences explain why the single photon double slit experiment is important. What principle does it prove and why?

8. What does the 'k' stand for in the equation $E_{out} = -i \cdot E_{in} e^{ikl}$. What is the definition of k?

9. How could you measure the difference between the |+i⟩ and |-i⟩ states if you could only measure in the Z basis but could apply any gate (rotation) you wanted to?

10. If a resonant Rabi Oscillation has a full period of 2π in T=20us then:

- **a)** What detuning needs to be added to create a Hadamard gate?
- **b)** What is the Hamiltonian being applied in the RWA?
- **c)** How long should that same amplitude of drive be applied to create a Hadamard gate?

11. What circuit is equivalent to a Z gate but is comprised of H and X gates?
Draw the rotation on the Bloch sphere of rotation of the $|+\rangle$ state to $|-\rangle$, using H and X gates:

12. Draw the rotation on the Bloch Sphere of a composite pulse sequence that reduces error from detuning noise when flipping $|0\rangle$ to $|1\rangle$. Write out the circuit of the composite pulse sequence.