1 Eigenvectors of the Rotation Matrix

The orthogonal matrix

$$R_z(\theta) = \begin{pmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

corresponds to a rotation around the z-axis by the angle θ.

(a) Find the eigenvalues of this matrix.

(b) Find the normalized eigenvectors of this matrix.

(c) Describe how the eigenvectors do or do not correspond to the vectors which are held constant or "only stretched" by this transformation.

2 Stern Gerlach Explain

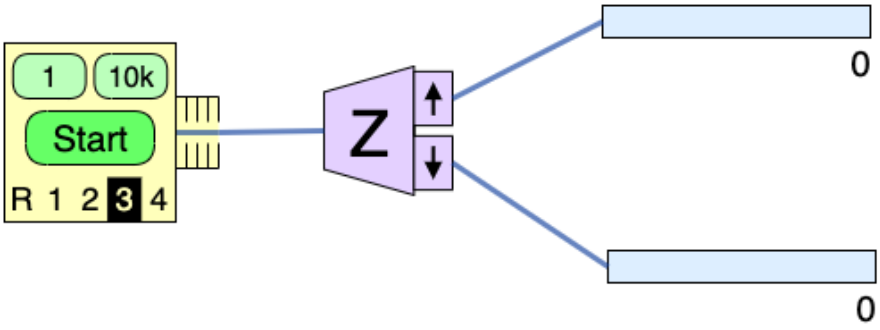
(a) Use words and equations to explain the key features of the Stern-Gerlach experiment.

(b) *Contrast Classical/Quantum* Explain what you would predict based only on classical physics for the Stern-Gerlach experiment and describe the difference between the classical prediction and the actual experimental results.

3 Statistical Analysis of the Spins Sim

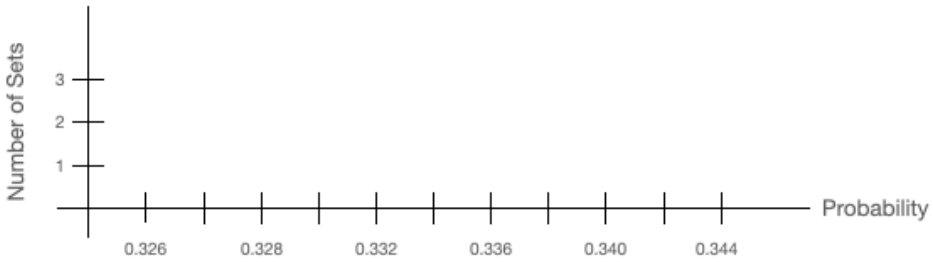
In the spins sim, the oven can be set to emit particles in a particular unknown prepared state (instead of in a random state).

- Set the oven to Unknown #3.
- Orient the analyzer in the z-direction.
- Perform 5 sets of 10,000 Stern-Gerlach experiments (10,000 particles are sent through a Stern-Gerlach Analyzer) and record the number of particles that end up in the top counter.
- For each set of experiments, calculate the probability that a single particle was measured to have $S_z = +\hbar/2$.



Do all of the following calculations by hand (you can use a calculator to help with the arithmetic).

(a) Plot a histogram of the probabilities you measured for each set. Use a bin size of 0.002 for the horizontal axis. (Choose appropriate values on the horizontal axis. You don't need to plot the full possible values 0-1. You may use a computer to make the histogram or you can sketch it by hand.)



(b) What is your best estimate of the probability that, when you measure S_z of a particle in the Unknown #3 state, you will get a result of $+\hbar/2$? Mark this value on your histogram.