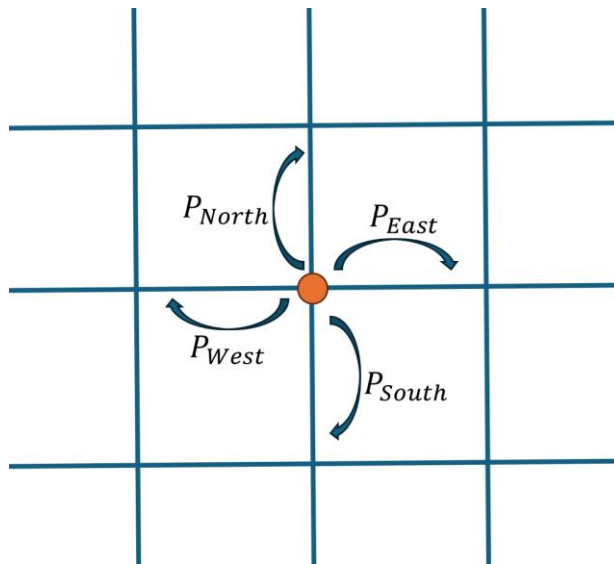


Computing For Physicists Test 4 (Final)

- 1) In using a column vector to represent the state of an 8-qubit circuit, $|\Psi\rangle = \begin{pmatrix} a_1 \\ a_2 \\ \vdots \\ \cdot \\ a_N \end{pmatrix}$,

how many complex numbers are required? In other words, what does N equal?

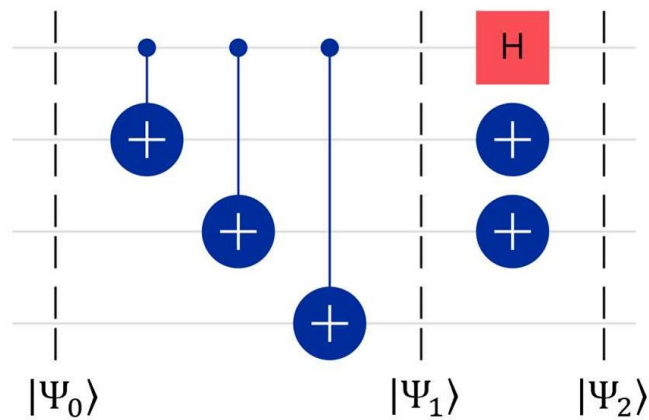
- 2) Someone undergoes a random walk starting at the origin of a two-dimensional grid:



Each second the walker randomly takes a single step in one of four directions North, South, East, or West. The probabilities the step is each direction are: $P_{North} = 0.28$, $P_{South} = 0.22$, $P_{East} = 0.28$, and $P_{West} = 0.22$.

- After **one hour**, what is the mean (x,y) position of the walker? (Note: steps of length 1 are taken and the +x direction is eastward and +y direction is northward)
- What is the standard deviation in the final x-position? What is the standard deviation in the final y-position?
- Construct a histogram of the final position. (Enough trajectories should be calculated such that resulting histogram is smooth).

3) For the following quantum circuit with initial wavevector, $|\Psi_0\rangle = \frac{|1001\rangle + |0110\rangle}{\sqrt{2}}$



a) What is $|\Psi_1\rangle$?

b) What is $|\Psi_2\rangle$?

4) The file Final_problem4_data.xlsx is an excel file containing three columns, x , $f(x)$, and errorbar which is intended to represent measurements of $f(x)$ and their associated error bars. The data has a number of problems: (1) some values of f are much too large, (2) some of the errorbars are negative, (3) some of the file just has garbage characters in it.

a) Clean up the file and plot $f(x)$ vs. x , including error bars.

b) Perform a χ^2 fit of $f(x) = a + bx + cx^3$ and report your determined values of a , b , and c .

c) Plot the cleaned-up data along with your fit line.

5) Two point masses, each of mass 1 kg , lie along the x-axis of a frictionless surface. Each mass experience a force due its position of $F = -x^3$. In addition to this force, the two masses repel each other with a force of magnitude $F_{\text{repel}} = \frac{1}{|10(x_2 - x_1)|^{13}}$

a) What are the 4 first order ODEs which need to be simultaneously solved in order to determine the trajectories of the two masses?

b) Given both masses start at rest and the initial positions of the masses of $x_1 = -2$ and $x_2 = 0$. Plot a plot of both x_1 and x_2 as a function of time.

c) Are both masses ever stationary at the same time (other than at $t = 0$)? If so, at what time?

6) Create a quantum circuit which creates the state, $|\Psi\rangle = \frac{|001\rangle + |111\rangle}{\sqrt{2}}$. (i.e., Determine the missing piece of the circuit below):

