## Qubit Mathematics:

One popular way of representing a qubit is with a column vector. These vectors are also known as kets. For our purposes, $|0\rangle$ represents the upward spin of an electron, while $|1\rangle$ represents its downward spin. In ket notation,

$$|0\rangle = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

and

$$|1\rangle = \begin{pmatrix} 0 \\ 1 \end{pmatrix}.$$

Why is this useful? Well, we generally use matrices to represent logic gates, as you soon will see.

## Our First Gate: Pauli-X gate

This is an excellent gate to start with because of its relation to the classical NOT gate. It can convert a spin down ($|1\rangle$) qubit to a spin up ($|0\rangle$) qubit. The key detail is the Pauli X matrix:

$$X = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

Thus,

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

and

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = \begin{pmatrix} 0 \\ 1 \end{pmatrix}.$$

This is our first foray into the world of quantum gates. Understanding these building blocks is essential to writing effective quantum algorithms.

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