QuantA&M Book Club

QuantA&M of Texas A&M University

A Brief Introduction

What is QuantA&M About?

The mission of QuantA&M is to connect students with the resources they need to learn more about the development, implementation, and application of quantum computing technology.

What is QuantA&M About?

The organization hopes to bring a new generation of inquisitive students to the forefront of quantum computing innovation as we enter a society which uses quantum computing as a mainstream method of solving complex problems.

Our Purpose

- At QuantA&M, we want every one of our members to use their experience in the student organization to increase their chances of success in applying for internships or other related experiences in the field of quantum computing.

Our Purpose

- Quantum computing is a small, but growing field. There are limited opportunities at the moment, meaning only those with good resumes will be accepted to the most enviable positions.

Our Purpose

- We want to encourage our members to get involved with QuantA&M. This organization is an opportunity to allow our fellow Aggies a means of involvement in this new and exciting field.

Getting Involved

Staying Updated

- To stay updated with QuantA&M, sign up to our official Discord.
- Other links to social media, along with our newsletter are provided in the discord

Quantum Projects

- Some potential ideas for a project are as follows:
  - Quantum Blog Post
    - Using the QuantA&M Website, members may submit a peer reviewed blog post about Quantum Computing topics.
  - Undergraduate research paper submission
    - With the assistance of QuantA&M, members can create, revise, and submit research articles to the various online and university resources available.
  - Github-related code projects with Quantum languages
    - Many quantum-related coding languages and modules currently exist and are ripe for innovation. Work together with fellow QuantA&M members and help develop code for Quantum Computing.

Future Book Club Meetings

- Book Club meetings will be covering the IBM-developed Qiskit module for Python. We will be covering the Qiskit textbook.

- Book club meetings are hosted biweekly on Wednesdays at 7-8PM. These are currently hosted by Zachary Lewis and Sam Bieberich.

- While this initial meeting is being hosted in Rudder Tower 301, future meetings will be held in Rudder Tower 308

Guest Speaker Seminars

- QuantA&M is planning to host seminars with leaders in the Quantum Computing industry.
- Stay tuned for more information.

Introduction to Quantum Computing

What is a Qubit?

- A qubit is the Quantum equivalent to a classical bit.
- Running certain algorithms via qubits is exponentially faster. This is due to a variety of reasons.

What is a Qubit– Continued

- A qubit is represented as follows:

$$a|1\rangle + b|0\rangle$$

What is a Qubit– Continued

- A qubit is represented as follows:

$$a|1\rangle + b|0\rangle$$

- The “a” and “b” are amplitudes, which when squared equal the probability of a 1 bit being measured or a 0 bit being measured.

Manipulating Qubits

- Qubits can be manipulated just like normal gates. However, there are certain unique gates that are available only to qubits.

Manipulating Qubits–The X (Not) Gate

- The X (aka the Not Gate) is simple. It inverts the value of a qubit.
- However, because qubits have nonbinary probabilities of the 0 and 1 state, this results in flipping the probability of measuring 0 and 1.

$$a|1\rangle + b|0\rangle \implies \boxed{X} \implies b|1\rangle + a|0\rangle$$

Manipulating Qubits– The C-Not Gate

- The C-Not gate (aka the Controlled-Not Gate) is also simple. The only distinction between it and the prior gate is that it has a control bit.
- If the control bit is 1, the C-Not gate activates. Otherwise, it does nothing.

$$C - bit = 1 : a|1\rangle + b|0\rangle \implies \boxed{CN} \implies b|1\rangle + a|0\rangle$$

$$C - bit = 0 : a|1\rangle + b|0\rangle \implies \boxed{CN} \implies a|1\rangle + b|0\rangle$$

Manipulating Qubits–The Hadamard Gate

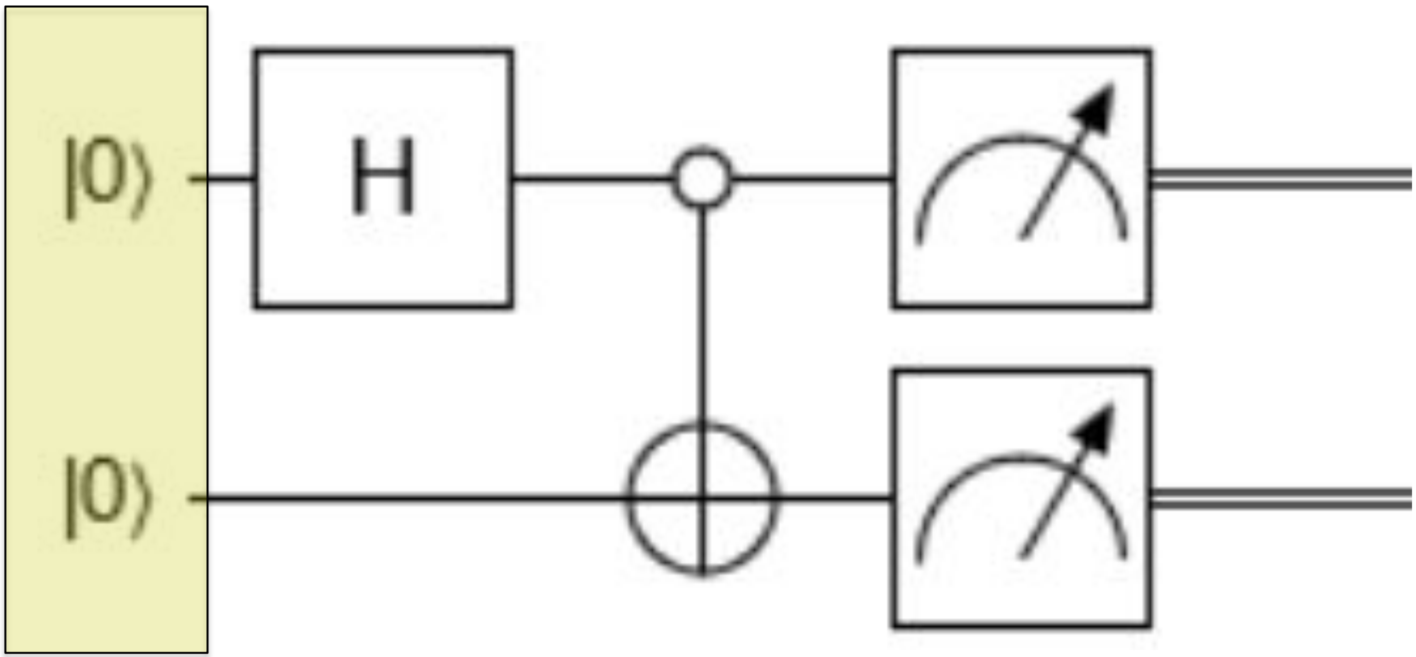
- The Hadamard gate is one of the most important gates in quantum computing.
- This gate changes qubit amplitudes such that the probability of getting a 0-bit or a 1-bit is equal.
- Remember: The probability is the amplitude squared.

$$|0\rangle \implies \boxed{H} \implies \frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle$$

$$|1\rangle \implies \boxed{H} \implies \frac{\sqrt{2}}{2}|0\rangle - \frac{\sqrt{2}}{2}|1\rangle$$

Quantum Circuits

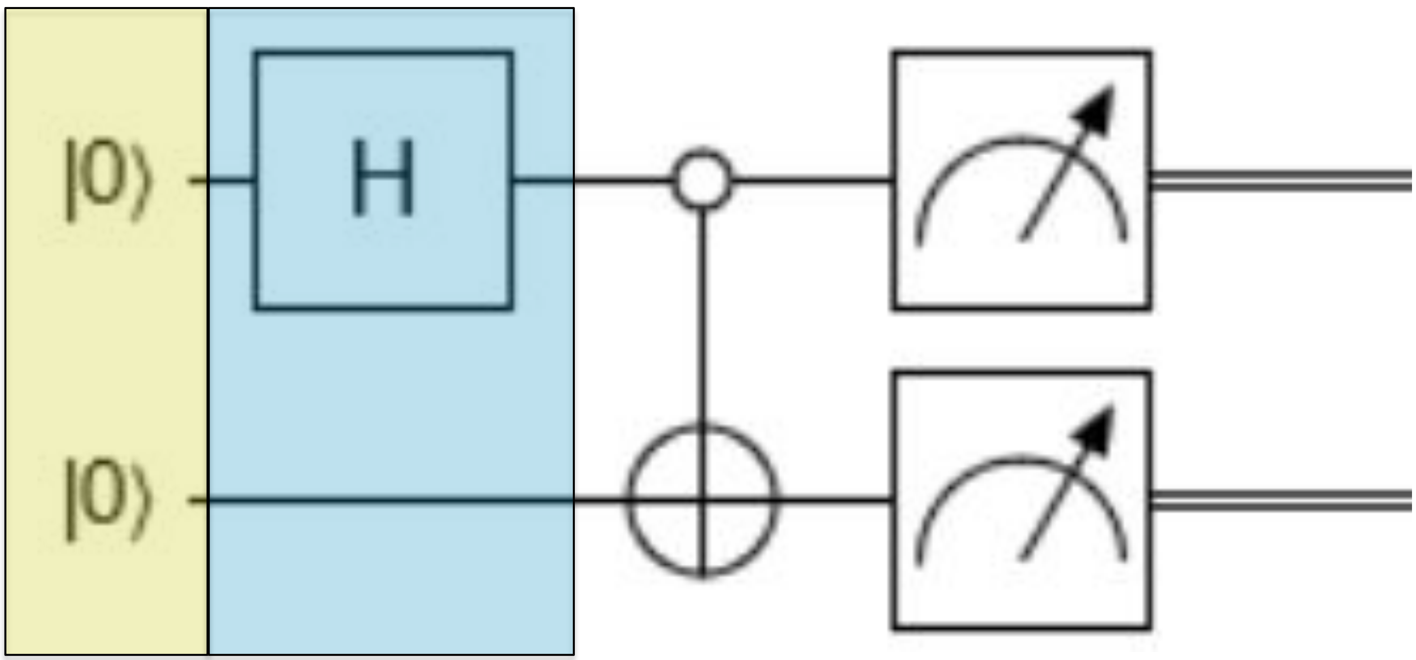
A Basic Quantum Circuit



$|0\rangle$

$|0\rangle$

A Basic Quantum Circuit



$|0\rangle$

$|0\rangle$

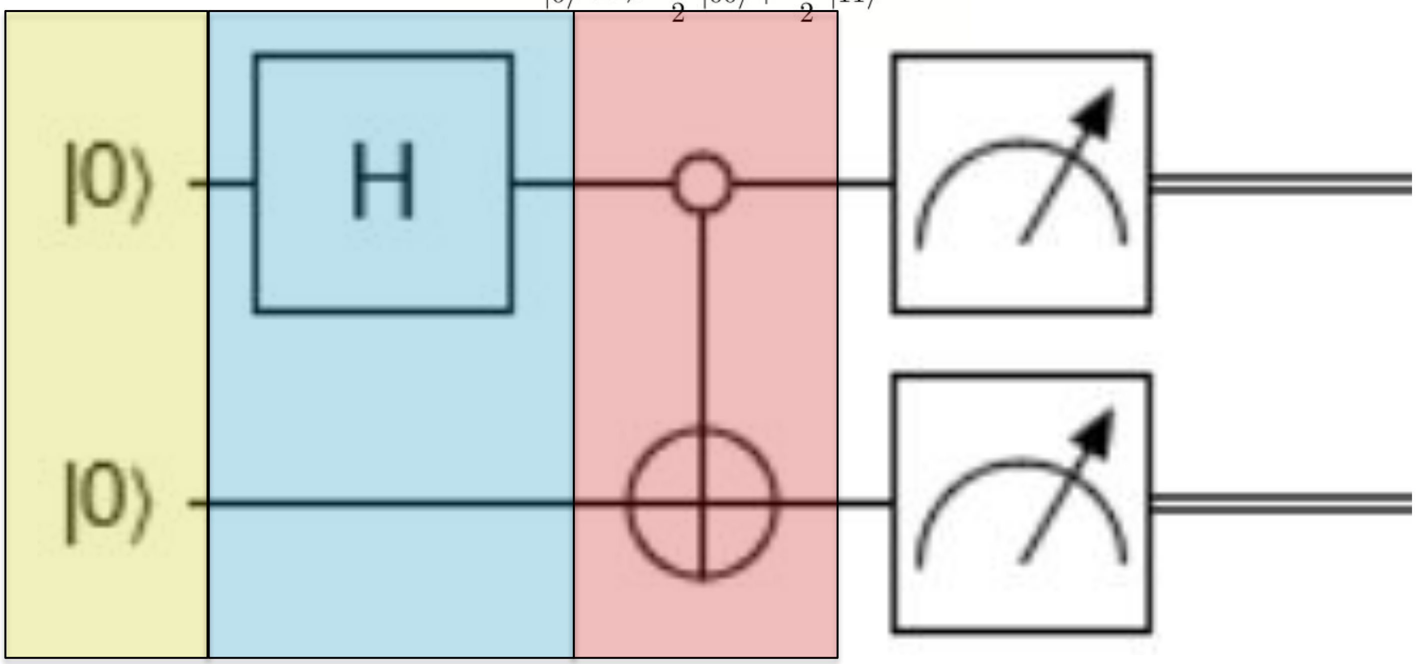
$$|0\rangle \implies \frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle$$

$$|0\rangle \implies |0\rangle$$

A Basic Quantum Circuit

$$\frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle \implies \frac{\sqrt{2}}{2}|00\rangle + \frac{\sqrt{2}}{2}|11\rangle$$

$$|0\rangle \implies \frac{\sqrt{2}}{2}|00\rangle + \frac{\sqrt{2}}{2}|11\rangle$$



$|0\rangle$

$|0\rangle$

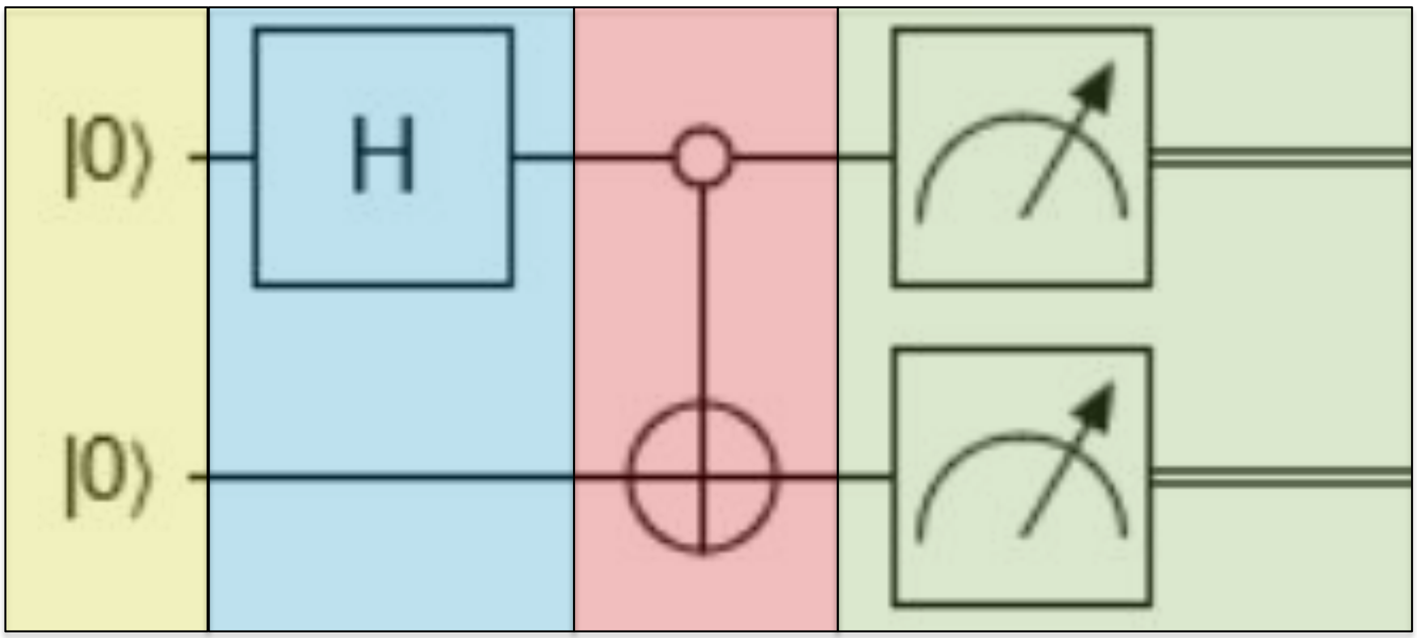
$$|0\rangle \implies \frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle$$

$$|0\rangle \implies |0\rangle$$

A Basic Quantum Circuit

$$\frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle \implies \frac{\sqrt{2}}{2}|00\rangle + \frac{\sqrt{2}}{2}|11\rangle$$

$$|0\rangle \implies \frac{\sqrt{2}}{2}|00\rangle + \frac{\sqrt{2}}{2}|11\rangle$$



$|0\rangle$

$|0\rangle$

$$|0\rangle \implies \frac{\sqrt{2}}{2}|0\rangle + \frac{\sqrt{2}}{2}|1\rangle$$

$$|0\rangle \implies |0\rangle$$

Classical Bit Measurement

How this all connects

- IBM’s Qiskit module heavily utilizes these circuits for their quantum computers.
- Everything you program in Qiskit will be converted from a quantum circuit to machine code.

Getting Started With Qiskit

Setup links

- IBM Account Creation:
  - https://quantum-computing.ibm.com/login
- IBM Jupyter Lab:
  - https://lab.quantum-computing.ibm.com/

Let’s Get Started