

Integrating Quantum Concepts into Cybersecurity

Activity 2: Qiskit (Quantum Information Science Kit)

Qiskit Programs – Joseph Spring

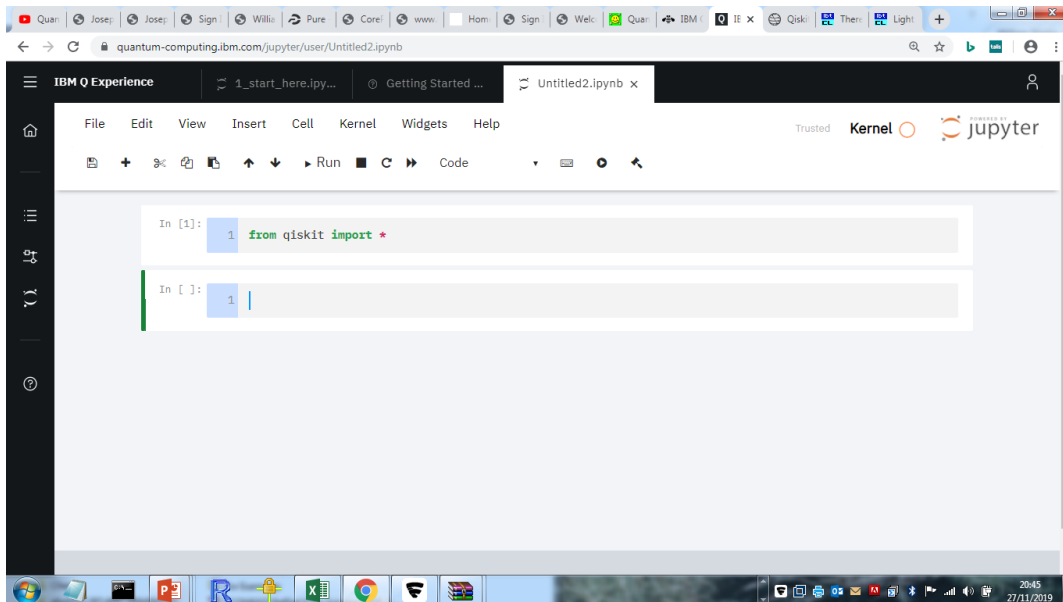
The following tutorial is based on Abraham Asfaw's Teleportation tutorial on Qiskit and YouTube

Exercise

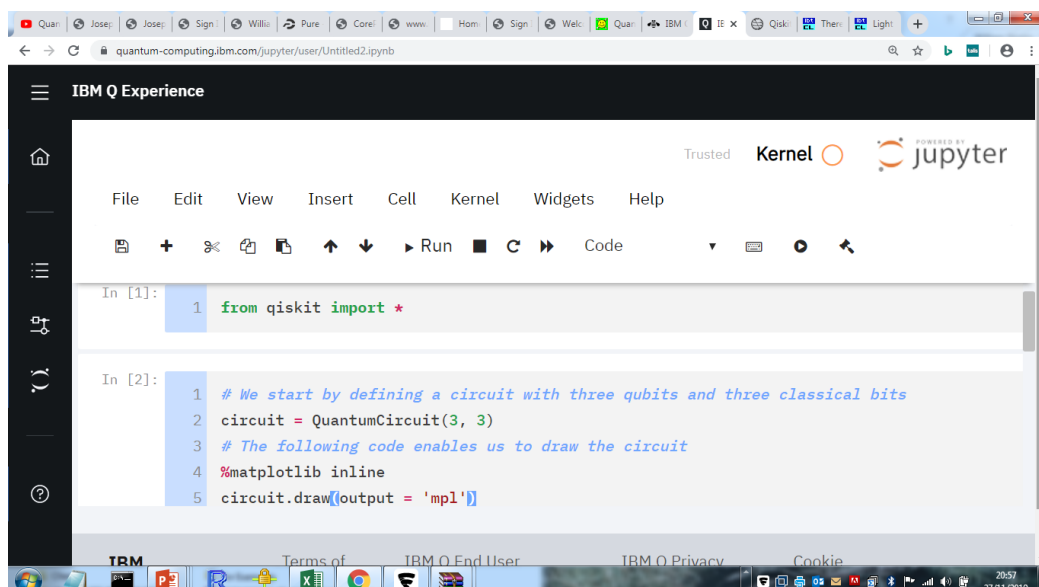
1. Draw the standard Teleportation Circuit

Tutorial

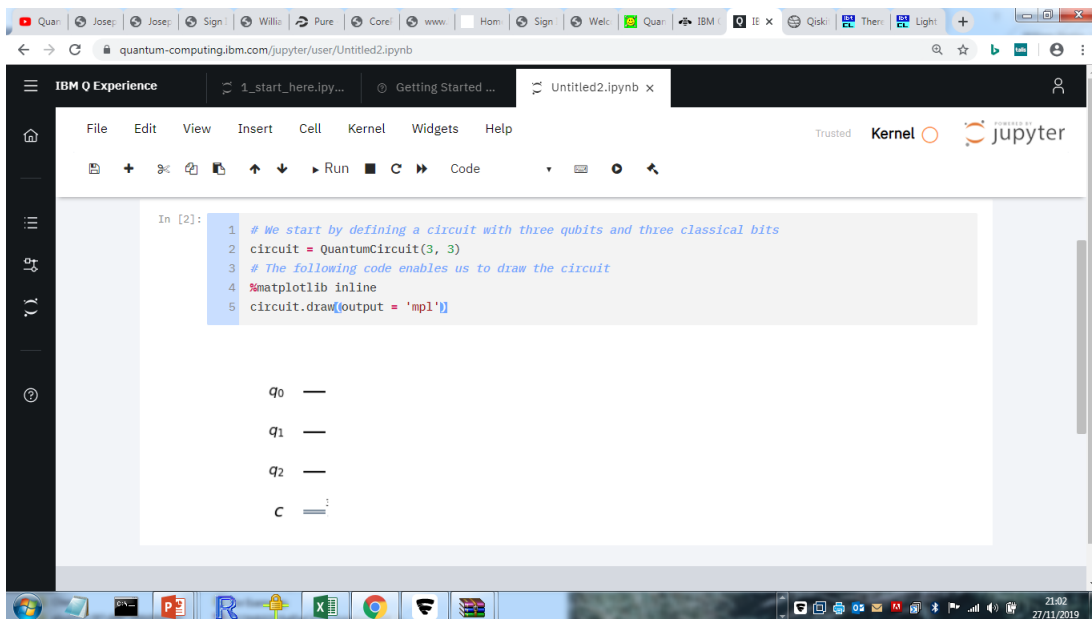
1. The following code is a variation on the previous examples of code that you have seen for including libraries. Type in the code and select Run. Compare the code we used previously for this stage



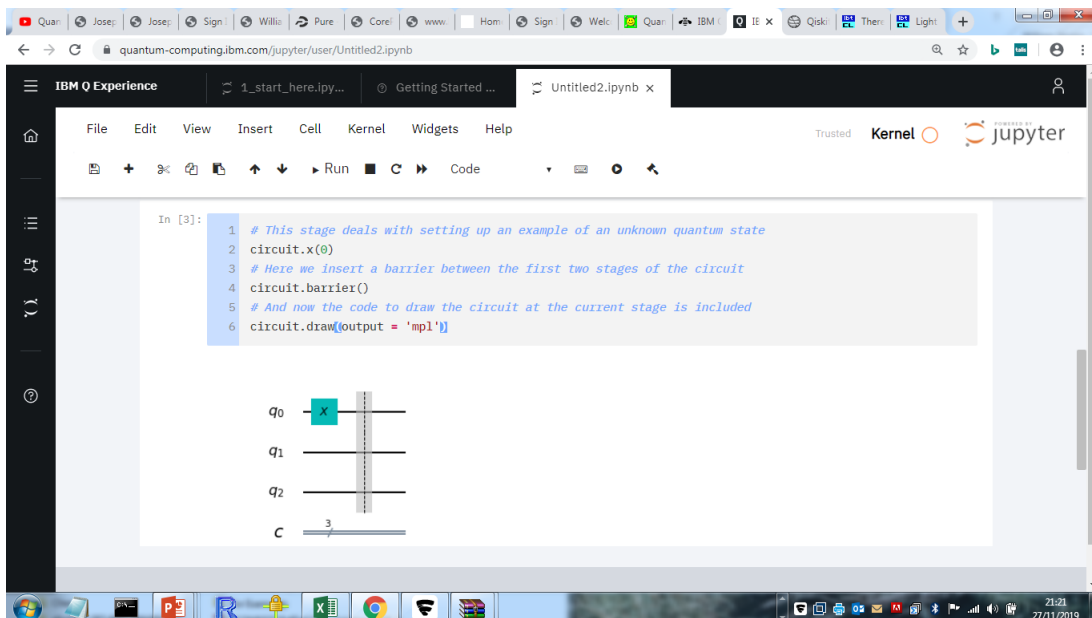
2. The following code defines the type of quantum circuit that we wish to use for the teleportation protocol



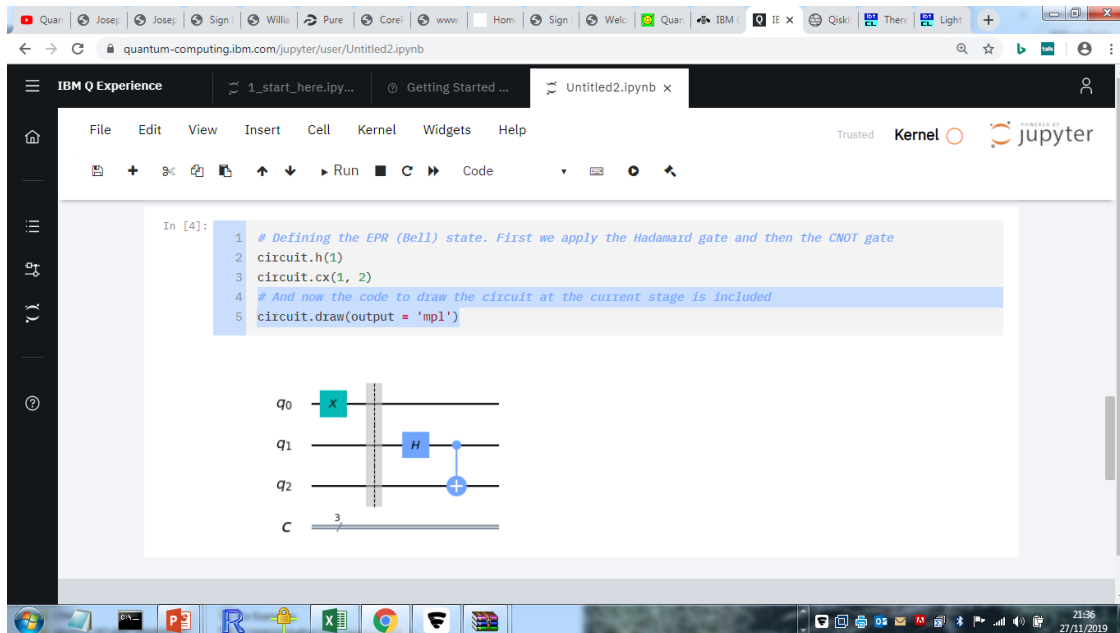
This has the following output for the circuit. Three qubits q_0 , q_1 , q_2 and c representing the three classical bits, c_0 , c_1 , and c_2 : Note that each qubit commences with the zero qubit $|0\rangle$



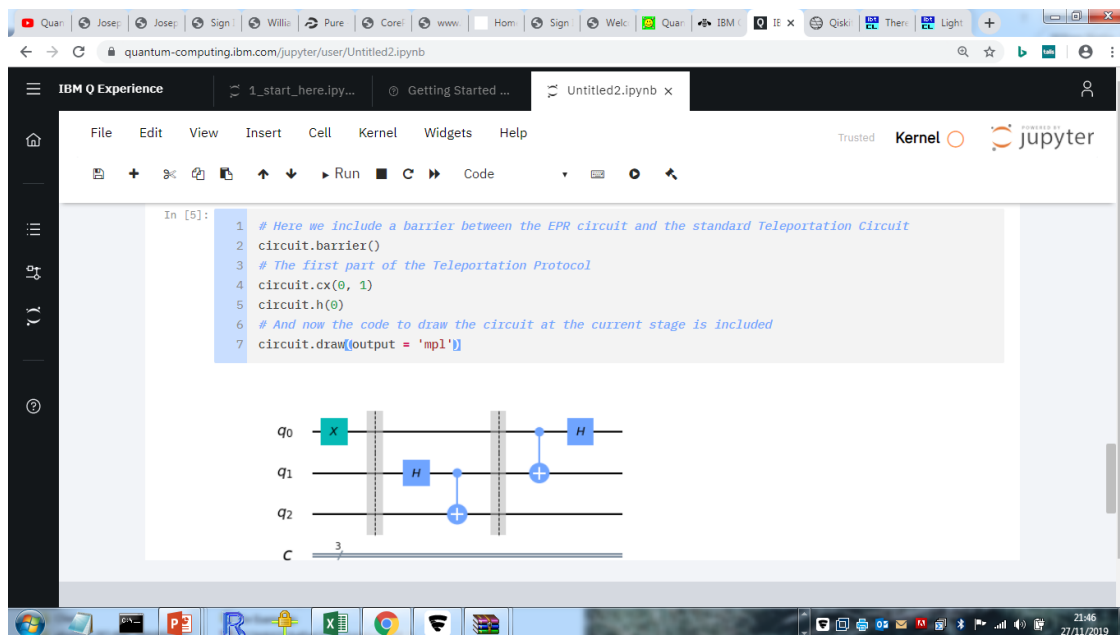
3. The next stage in the code deals with the defining an example of an unknown state. We want to start with the unknown qubit state $|1\rangle$, so we need to apply the Pauli NOT gate X to q_0 :



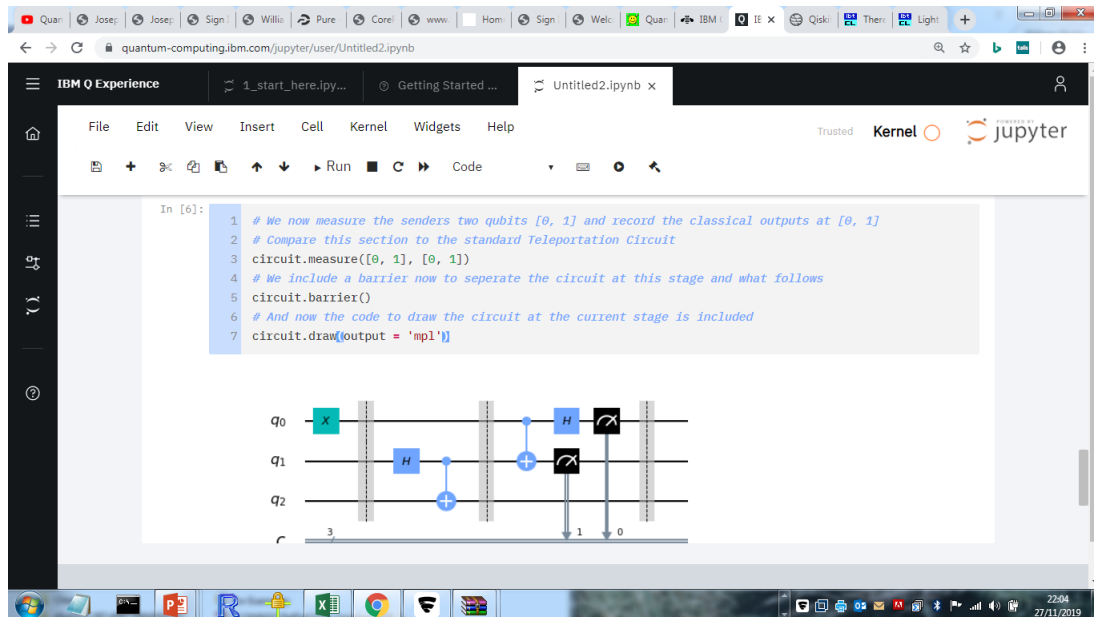
4. The next stage is to define the EPR (Bell) state that we will use in the teleportation protocol. This is defined between the sender (q_1) and receiver (q_2). The circuit shown is the output for this stage of the protocol



5. The following code defines the first part of the Teleportation Protocol



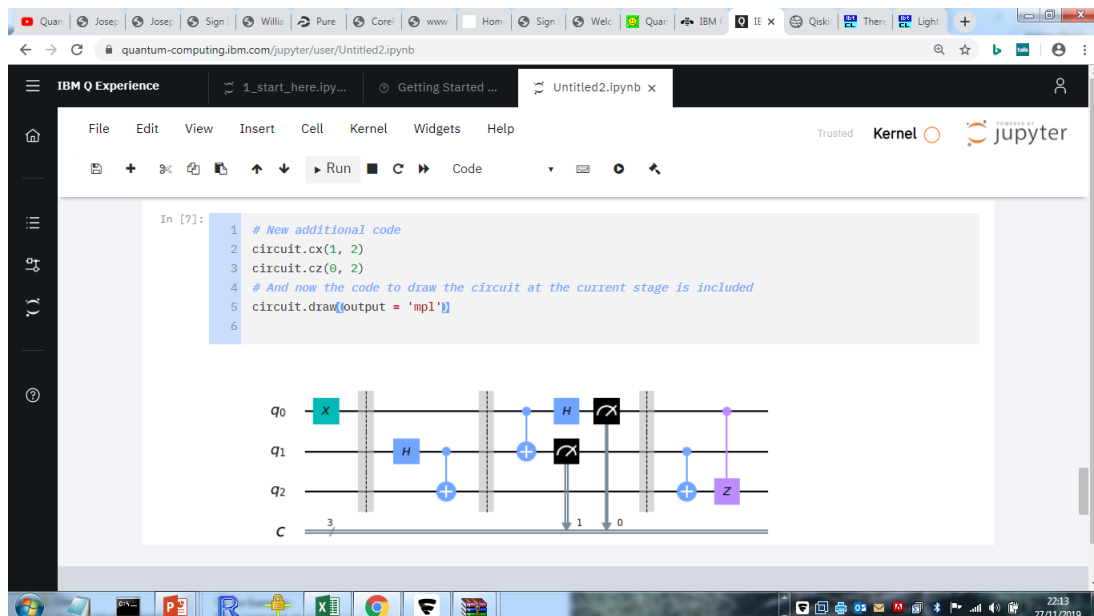
6. The next stage is to measure each of the qubits at the sender's side (at q_0 and q_1).



Question. What does the 0 and 1 denote on the classical part of this circuit?

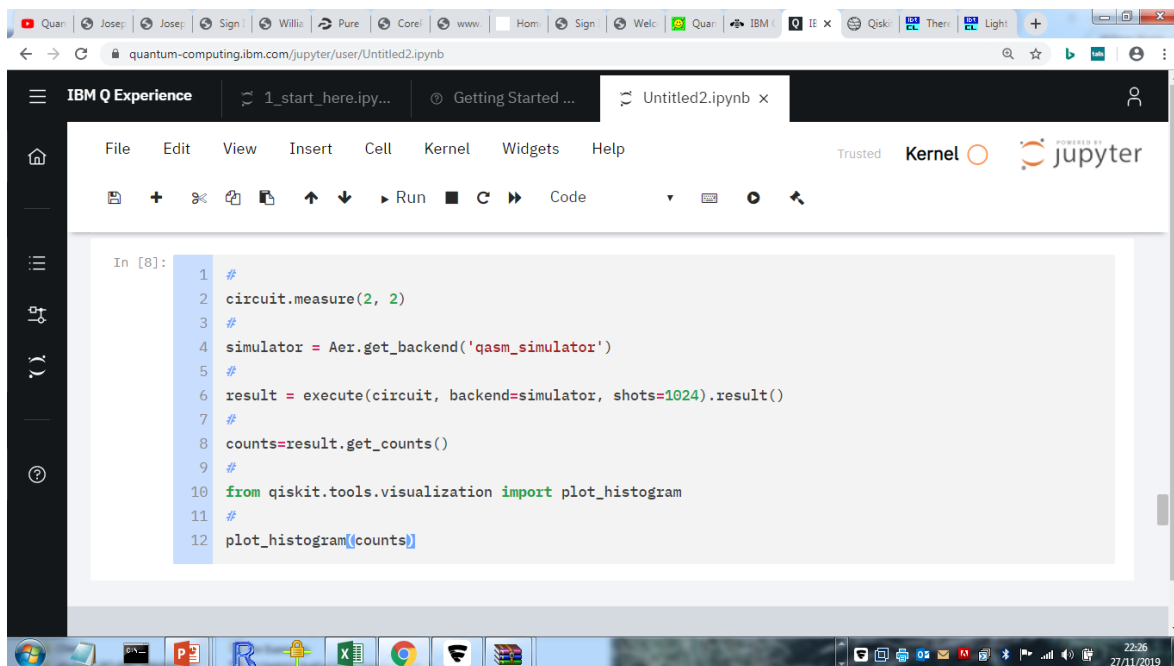
From this point on explain what is happening for each line of code.

7. Additional gates are added to the circuit; a CNOT gate and a Controlled Z gate



Question. What are the additional gates doing?

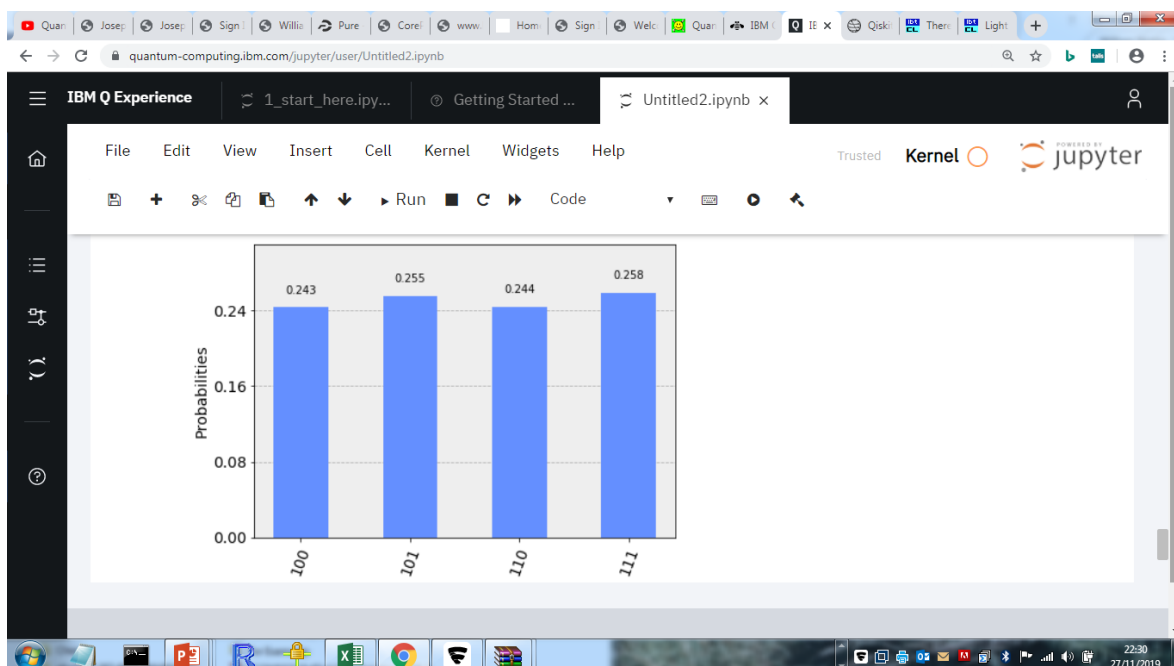
8. Finally we add the following code



```
In [8]: 1 #
2 circuit.measure(2, 2)
3 #
4 simulator = Aer.get_backend('qasm_simulator')
5 #
6 result = execute(circuit, backend=simulator, shots=1024).result()
7 #
8 counts=result.get_counts()
9 #
10 from qiskit.tools.visualization import plot_histogram
11 #
12 plot_histogram(counts)
```

Question. What is each line of the above code doing?

9. The above code outputs the following histogram:



Question. What does the histogram show?

Exercise

How would the above code change if the unknown state was the $|+\rangle$ state rather than a $|1\rangle$ state?

Circuit Composer

The circuit composer is an option available to help develop skills in creating quantum circuits in the IBM Q Experience.

In this section I would like you to create a new circuit. This should give you access to two tutorials. The first being the Composer Guide and the second a Gates overview. The composer guide runs through the *Hello Quantum World* Program. This we have met as the EPR circuit.

1. For your first circuit I would like you to Create the EPR circuit. Save and run the circuit. You will be asked for the backend that you would like to use. Does it matter which you use?
2. Now work through the Composer Guide. Compare the approach taken in the composer guide to the approach that you took with the EPR circuit above.
3. Now work through the Gates Overview. Which gates are familiar and which are not so familiar?

References

1. <https://quantum-computing.ibm.com/support/guides/getting-started-with-qiskit-notebooks?section=5cd027ee555a22003bf5957e#>
2. <https://www.youtube.com/watch?v=mMwovHK2NrE>