Homework 11 (IBMQ)

(1b)

steps

Click here to run your circuit on real devices or simulators.

your jobs show up here

Choose devices
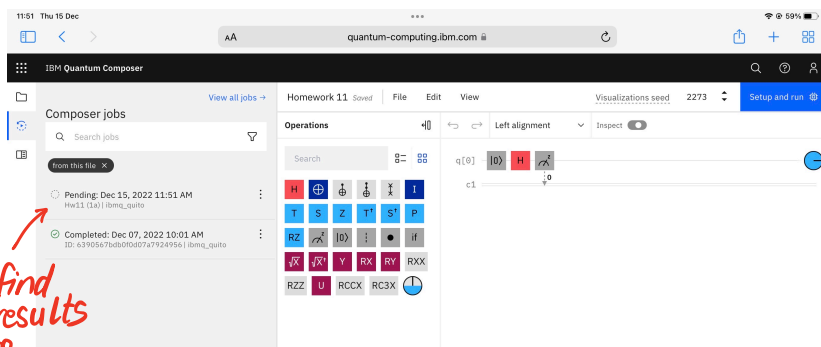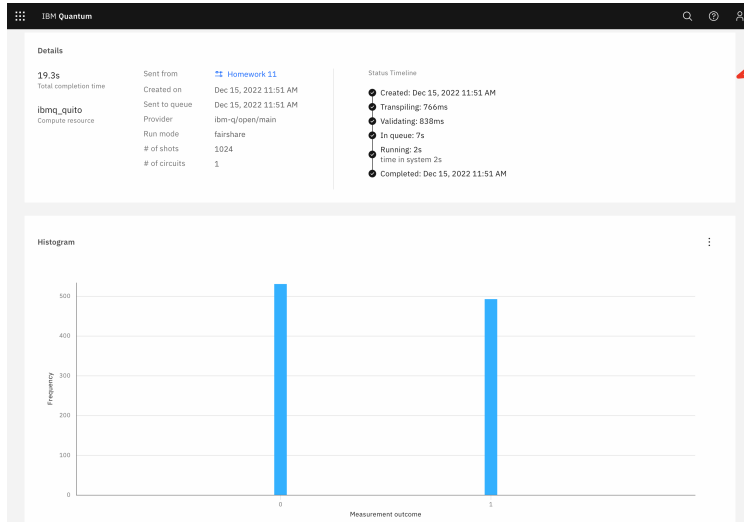
choose number of shots

RUN!
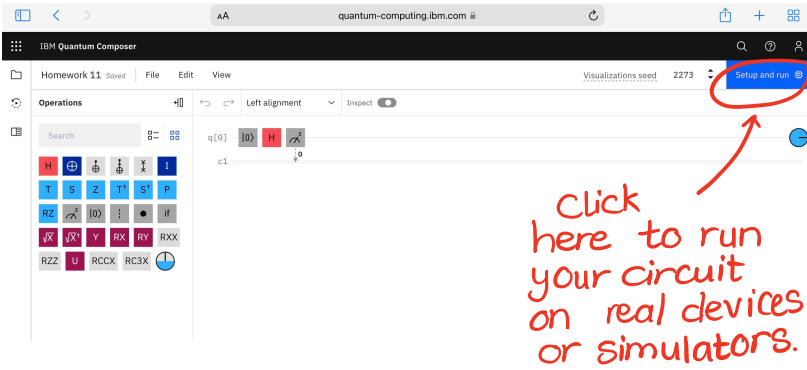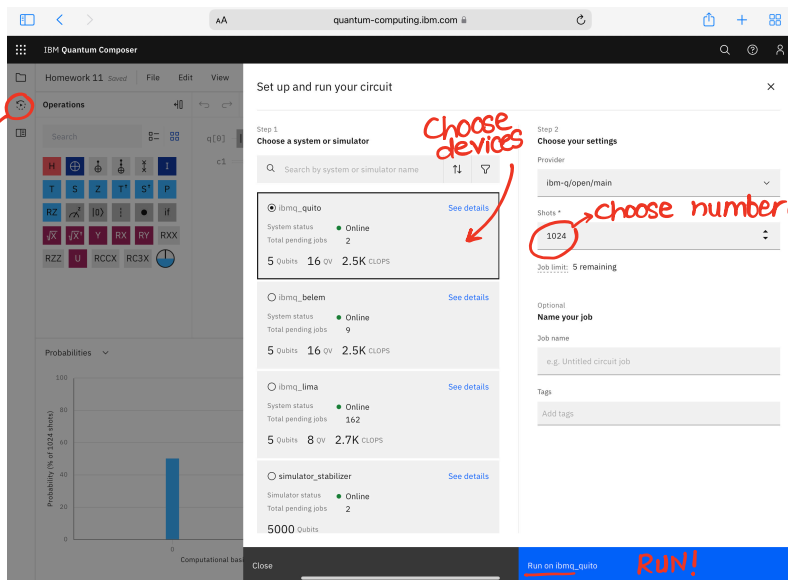
you can find your results here

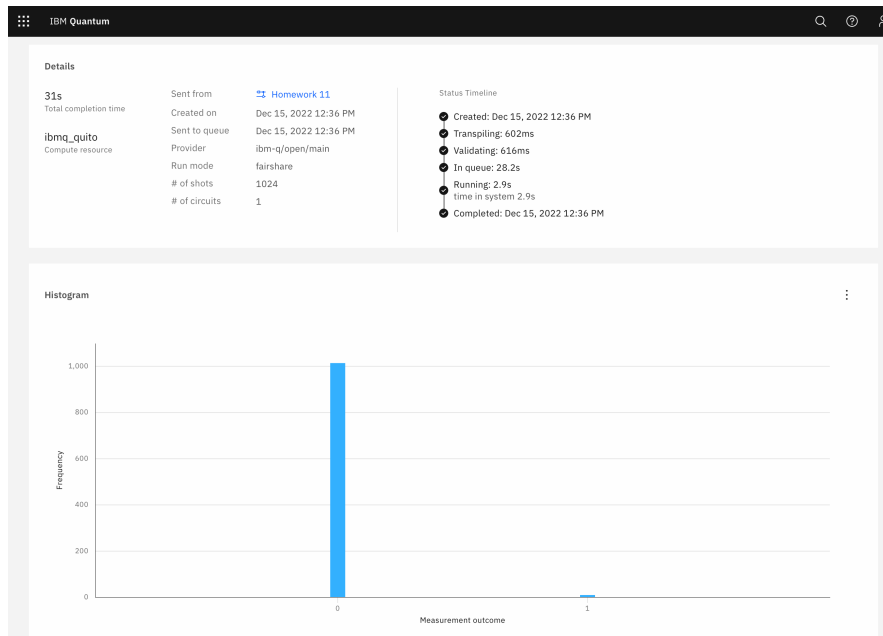Results of running circuit (1b) on real device (ibm quito)

* the output state is $\frac{|0\rangle + |1\rangle}{\sqrt{2}}$, thus Getting 0 and 1 roughly an equal number of times matches our expectation.
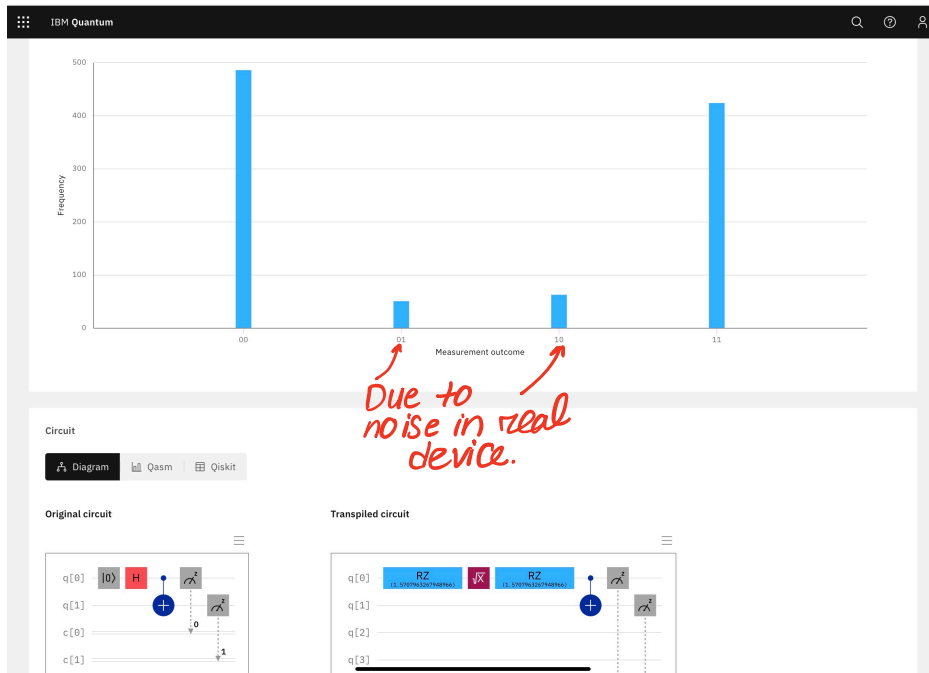

(1C)

to add extra
qubits, click on
q[0]

(1d)

Circuit

Diagram | Qasm | Qiskit

Original circuit

output state: $\frac{1}{2} (|00\rangle + |10\rangle + |01\rangle - |11\rangle)$

(1e)

Due to
noise in real
device.

Circuit

Diagram | Qasm | Qiskit

Original circuit

q[0] |0⟩ H
q[1]   ⊕
c[0]
c[1]

Transpiled circuit

q[0] RZ (1.5707963267948966) √X RZ (1.5707963267948966)
q[1]   ⊕
q[2]
q[3]

Output state : $\frac{|00⟩ + |11⟩}{\sqrt{2}}$, so we should see
the outcome '00' with prob. $\frac{1}{2}$
and "   " '11' " " $\frac{1}{2}$.

(1f) W-state as seen in homework 8 (Exercise 4):

$$|W\rangle = \frac{1}{\sqrt{3}}\left(|100\rangle + |010\rangle + |001\rangle\right)$$

https://en.wikipedia.org/wiki/W_state

this Gate should have $\Theta = 2\cos^{-1}\left(\frac{1}{\sqrt{3}}\right) \approx 1.9106\ldots$

↑ this is an approximation (so less accurate)

use this to make control-H gate (by dragging it over H gate in circuit)
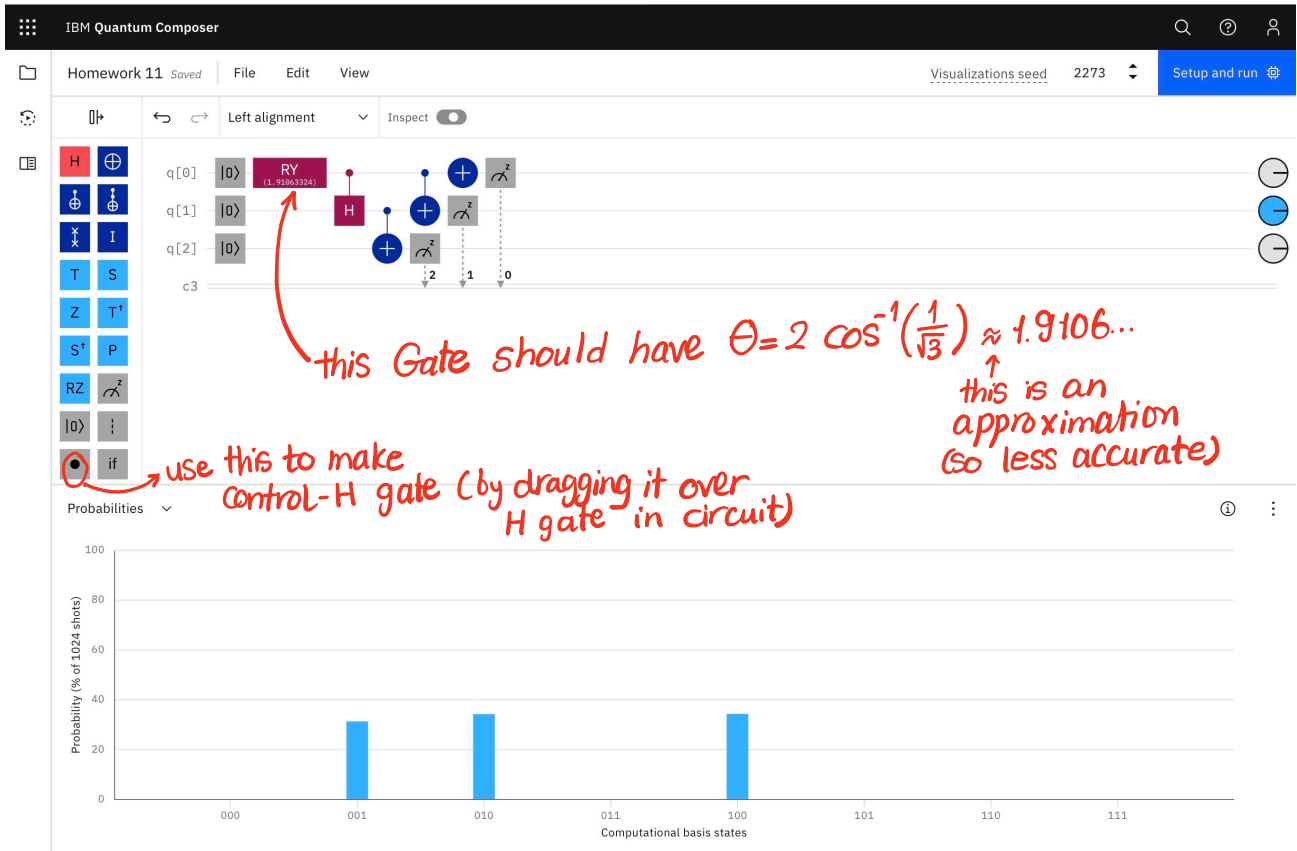
* Analyzing the circuit, we see:

$$|000\rangle \xrightarrow{R_Y\left(2\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)\right)} \frac{1}{\sqrt{3}}|000\rangle + \sqrt{\frac{2}{3}}|100\rangle$$
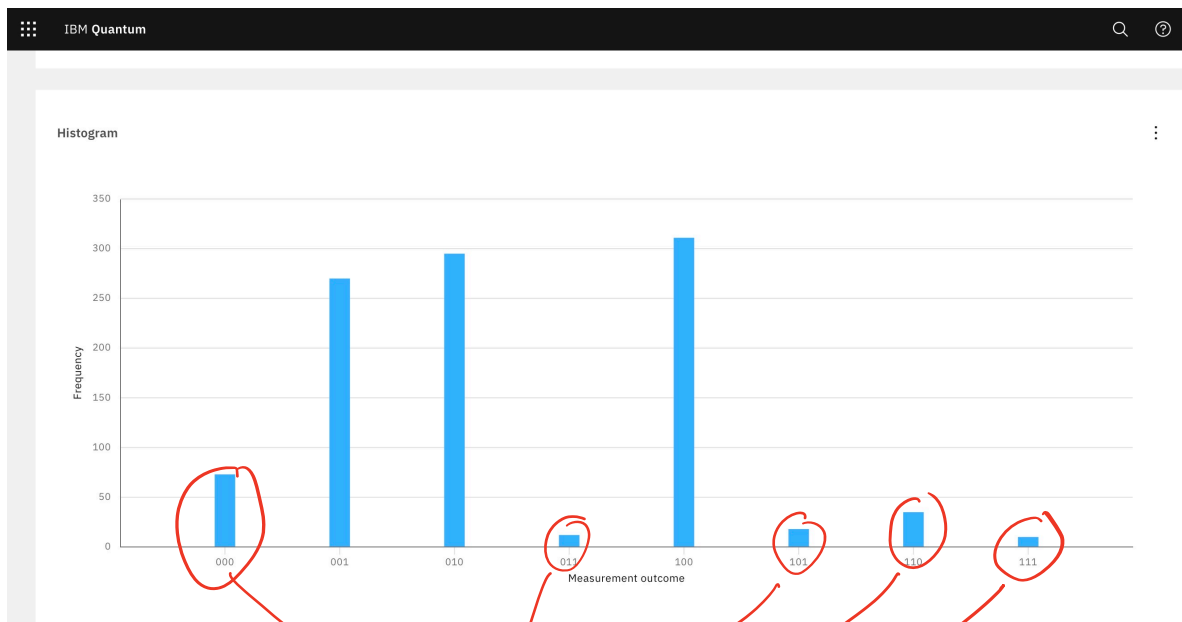
$$\xrightarrow{\text{control-H}} \frac{1}{\sqrt{3}}|000\rangle + \sqrt{\frac{2}{3}}\left(|1\rangle \otimes \frac{|0\rangle + |1\rangle}{\sqrt{2}} \otimes |0\rangle\right)$$

$$\xrightarrow{\text{CNOT}} \frac{1}{\sqrt{3}}|000\rangle + \sqrt{\frac{1}{3}}\left(|100\rangle + |111\rangle\right)$$

$$\xrightarrow{\text{CNOT}} \frac{1}{\sqrt{3}}|000\rangle + \sqrt{\frac{1}{3}}\left(|110\rangle + |101\rangle\right)$$

$$\xrightarrow{\text{NOT} \oplus} \frac{1}{\sqrt{3}}\left(|100\rangle + |010\rangle + |001\rangle\right)$$

⋆ Results on Real Device:

IBM Quantum

Histogram

(Histogram with Frequency on y-axis from 0 to 350 and Measurement outcome on x-axis with values 000, 001, 010, 011, 100, 101, 110, 111)

noise effect