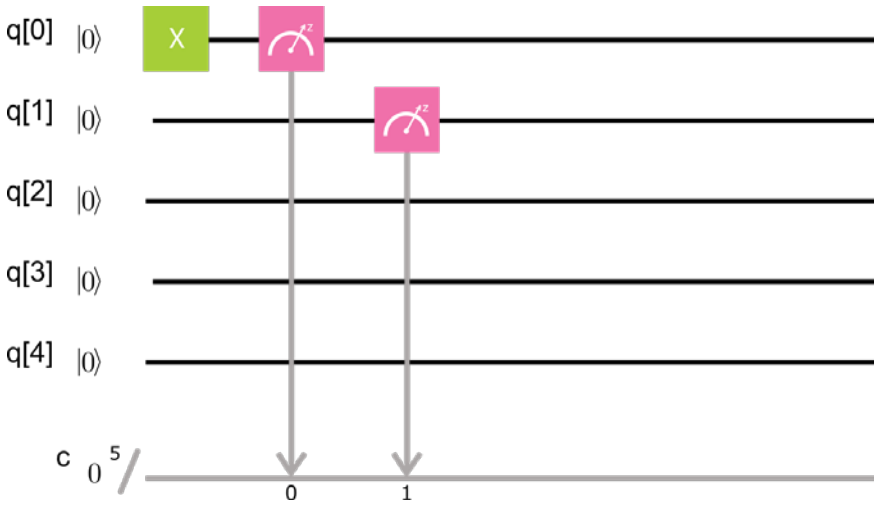
Single-Qubit Gates

The IBM platform enables you to perform single-qubit and two-qubit operations. Table 1 shows the predefined single-qubit gates and the QASM line to apply them on qubit q[0]. You can extrapolate the idea for other qubits.

Table:1

Gate	QASM line
$X = \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$	x q[0];
$Y = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$	y q[0];
$Z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$	z q[0];
$H = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}$	h q[0];
$S = \begin{pmatrix} 1 & 0 \\ 0 & e^{i\frac{\pi}{2}} \end{pmatrix}$	s q[0];
$S^\dagger = \begin{pmatrix} 1 & 0 \\ 0 & -e^{i\frac{\pi}{2}} \end{pmatrix}$	sdg q[0];
$T \begin{pmatrix} 1 & 0 \\ 0 & e^{i\frac{\pi}{4}} \end{pmatrix}$	t q[0];
$T^\dagger \begin{pmatrix} 1 & 0 \\ 0 & -e^{i\frac{\pi}{4}} \end{pmatrix}$	tdg q[0];

In the figure below, an X-gate is applied on the first qubit q[0], and then q[0] and q[1] are measured. The final state of the two-qubit system is given by |10⟩.



The code below generates the above quantum circuit. Note that there are two blank lines, 4 and 6, this is just to make the code look cleaner. In this way, you will have a first section in which you define your registers, a second section in which you apply the quantum gates, and a third section in which you measure.

```
1 include "qelib1.inc";
2 qeg q[5];
3 creg c[5];
4
5 x q[0];
6
7 measure q[0] -> c[0];
8 measure q[1] -> c[1];
```

Table 2 shows the results of running the code 1024 times on the perfect quantum simulator. From here you can notice that the two qubits were projected onto state |10⟩ every time.

Table:2

c[5]	n
01	1024

Table 3 shows the results of running the code 1024 times on a real IBM quantum computer. From here you can notice that the two qubits were projected onto state |00⟩ 70 times, onto state |01⟩ 2 times, onto state |10⟩ 941 times, and onto state |11⟩ 11 times. The difference between the results in tables 2 and 3 are not only given by the errors in the measurements but also by the error in the X-gate.

Table:3

c[5]	n
00	70
01	941
10	2
11	11