Logic Gates - A Classical Approach to Quantum Circuits

Schedule, Rules, Guidelines

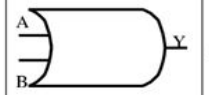
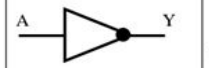
What That Gate Do??

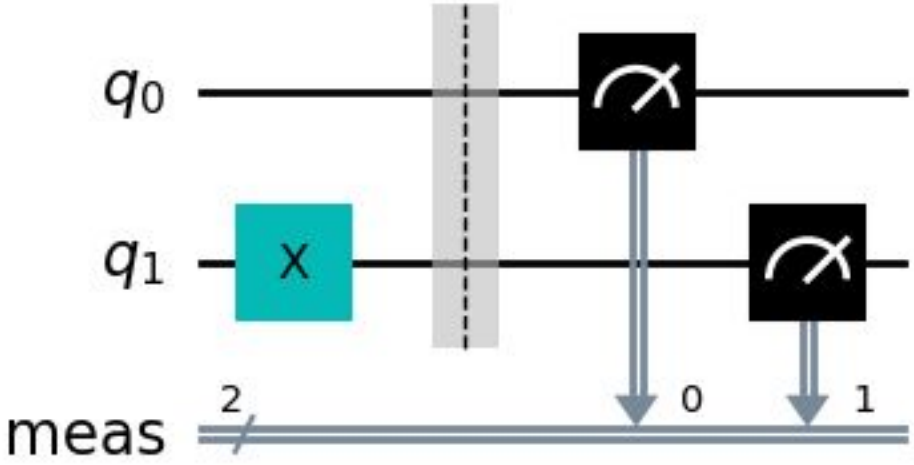
- A logic gate is **a device that acts as a building block for digital circuits**. They perform basic logical functions that are fundamental to digital circuits.

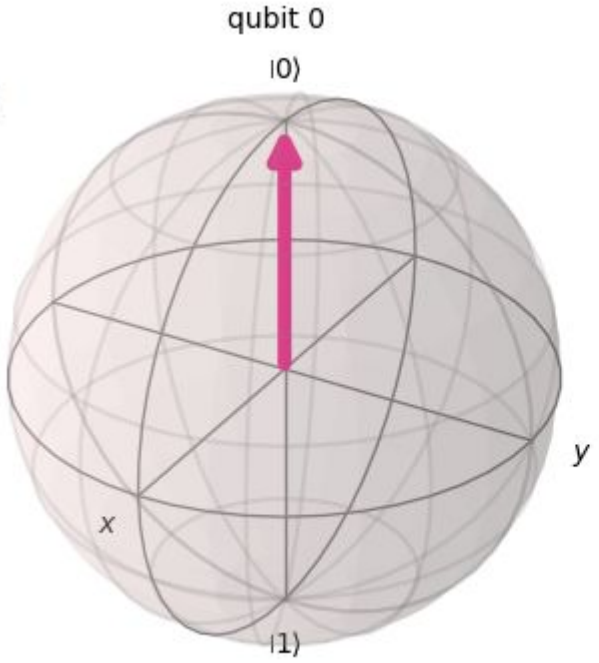
- Logic gates are used to carry out logical operations on single or multiple binary inputs and give one binary output.

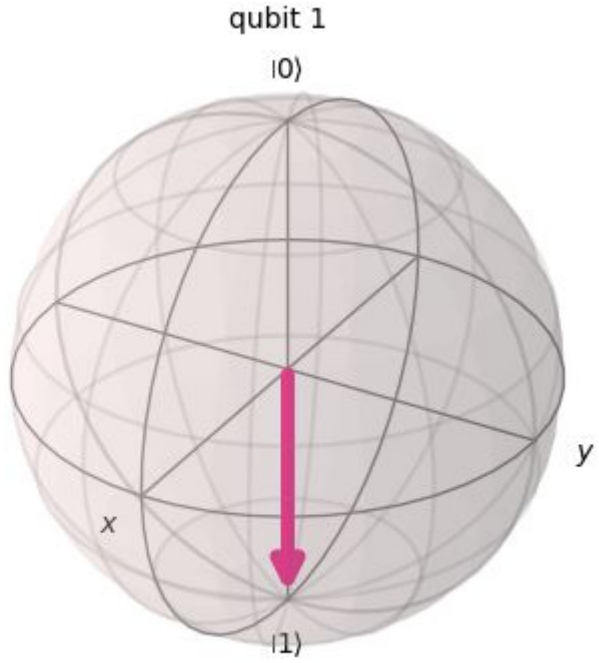
- ***What about on Quantum Circuits???*** Quantum Computers also act as universal classical devices, all logic gates can be implemented in a Quantum Circuit.

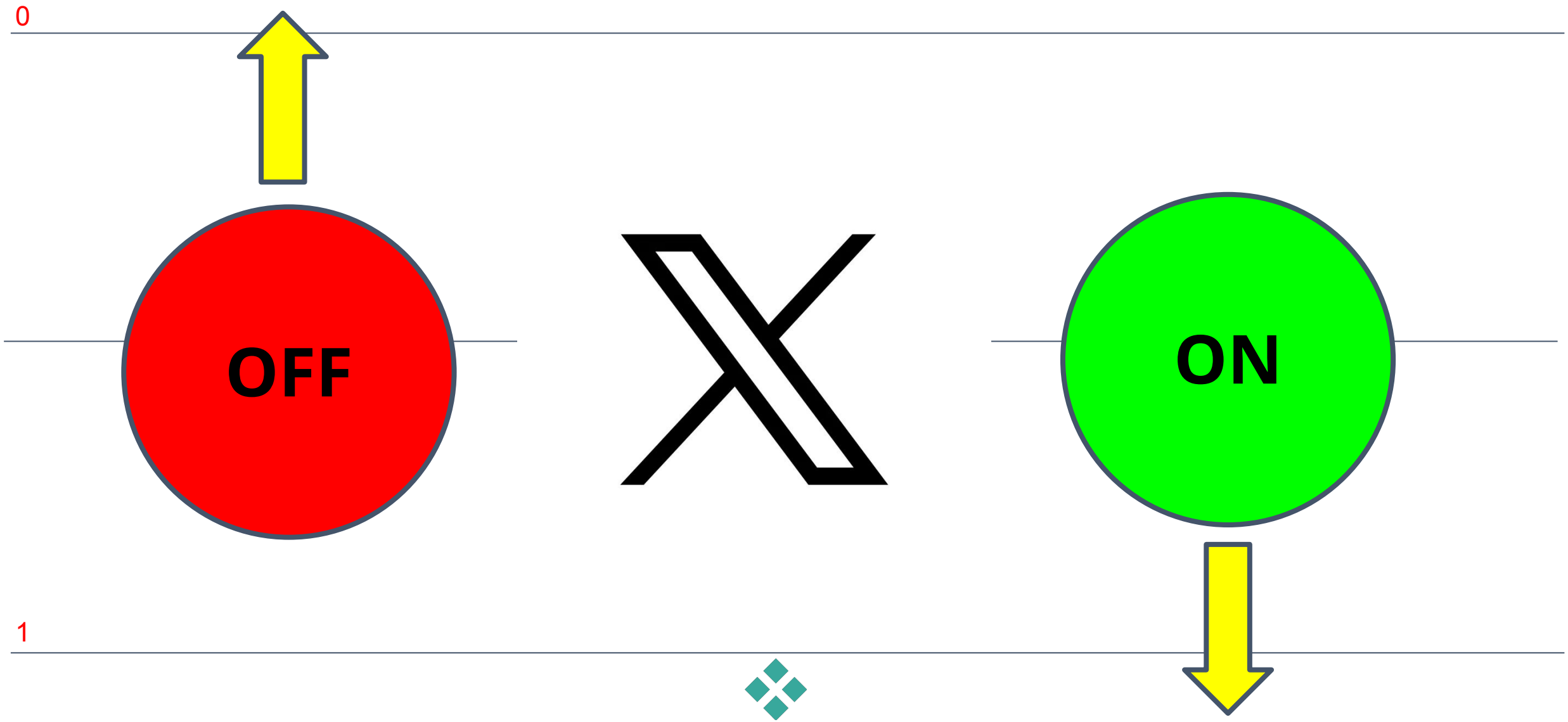
Basic Logic Gates

Logic	Schematic	Boolean Expression	Truth Table	English Expression
AND		$A \bullet B = Y$	A B Y 0 0 0 1 1 0 1 1	The only time the output is positive is when all the inputs are positive.
OR		$A + B = Y$	A B Y 0 0 0 1 1 0 1 1	The output will be positive when any one or all inputs are positive.
XOR		$A \oplus B = Y$	A B Y 0 0 0 1 1 0 1 1	The only time the output is positive is when the inputs are not the same.
NOT		$\bar{A} = Y$	A Y 0 1	The output is the opposite of the input.
NAND		$\overline{A \bullet B} = Y$	A B Y 0 0 0 1 1 0 1 1	The output is positive provided all the inputs are not positive.
NOR		$\overline{A + B} = Y$	A B Y 0 0 0 1 1 0 1 1	The only time the output is positive is when all the inputs are negative.
XNOR		$\overline{A \oplus B} = Y$	A B Y 0 0 0 1 1 0 1 1	The only time the output is positive is when all the inputs are the same.


q_0
q_1
X
meas
2
0
1


qubit 0
|0⟩
x
y
|1⟩


qubit 1
|0⟩
x
y
|1⟩


0
OFF
ON
1

Logic From Truth Tables

A	B	OUTPUT
0	0	0
0	1	1
1	0	1
1	1	1

OR

A	B	OUTPUT
0	0	0
0	1	0
1	0	0
1	1	1

AND

NOT(XGate)

A	OUTPUT
0	1
1	0

A	B	OUTPUT
0	0	1
0	1	0
1	0	0
1	1	0

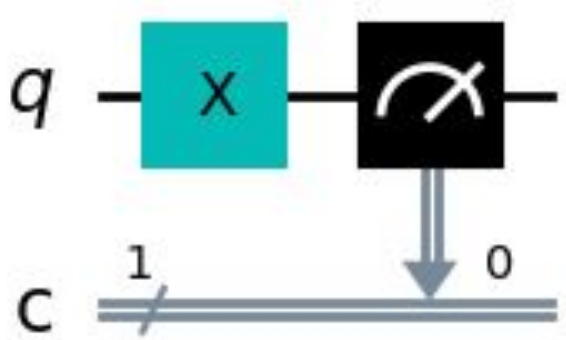
NOR

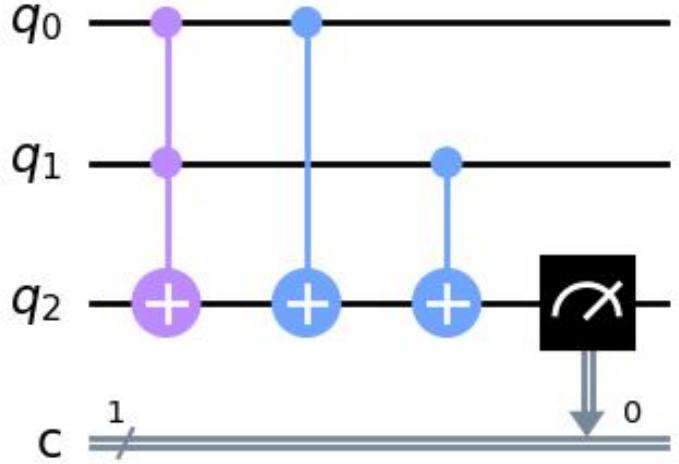
A	B	OUTPUT
0	0	1
0	1	1
1	0	1
1	1	0

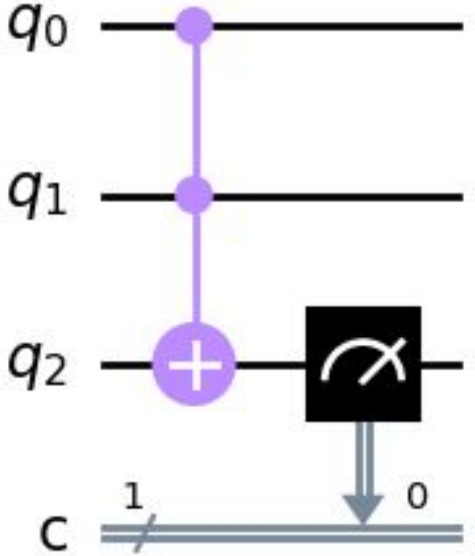
NAND

NOT, AND, OR

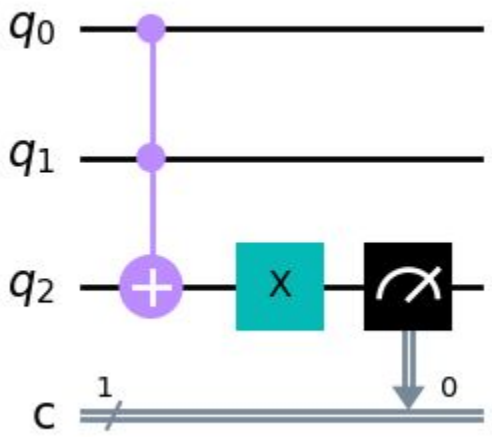
- Circuit Diagrams can be traced in some instances
- This allows to determine the logic of the circuit without simulating or running the circuit
- Trace the circuits to determine which circuit diagram is associate with the three basic logical gates (operations)

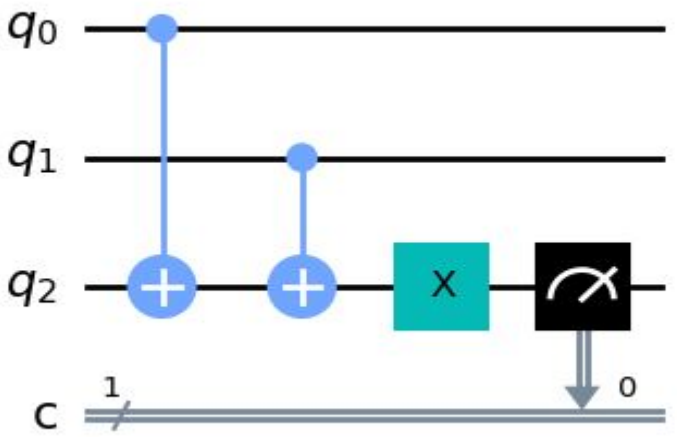


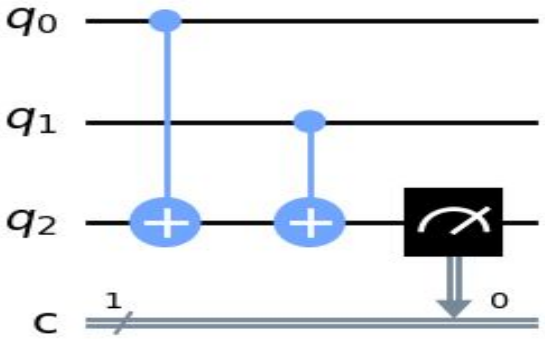




NAND, NOR, XOR, XNOR



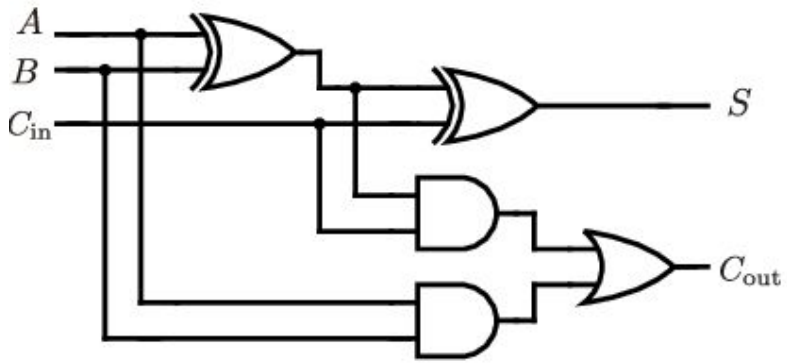




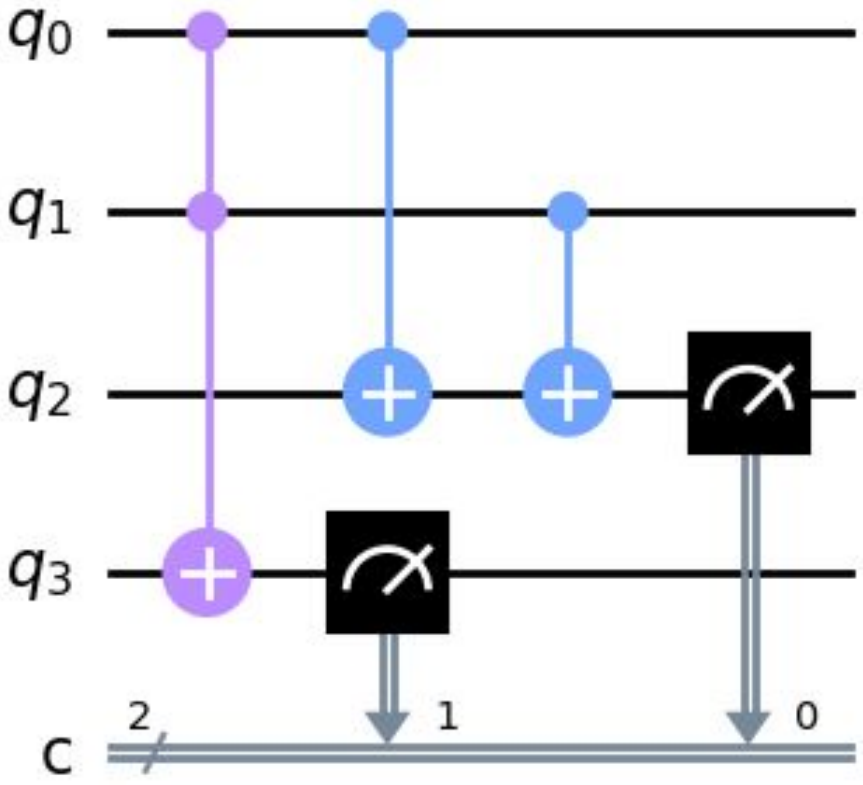
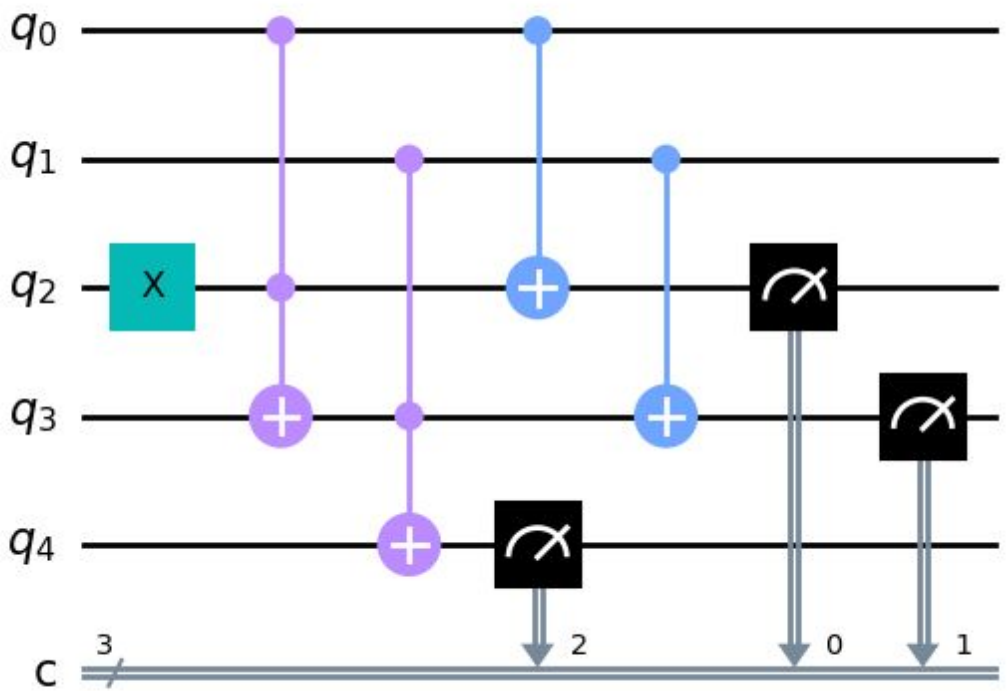
Adder Circuit

- An **adder**, or **summer**,is a digital circuit that performs addition of numbers. It can also subtract numbers using 2's-complement. Binary subtraction is addition of a negative number.

- In many computers and other kinds of processors adders are used in the arithmetic logic units (ALUs). They are also used in other parts of the processor, where they are used to calculate addresses, table indices, increment and decrement operators and similar operations.



Inputs			Outputs	
A	B	C_{in}	S	C_{out}
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Two Different Quantum Adders - Two Qubits

- Circuit one takes two qubits and returns the value of q_0 + q_1
- Circuit two takes one qubit string of size 2 and increments the value by 1