Lesson II Quantum Computing

Wed 31 Oct 2018

(· Review yesterday)

· Rub 8 Quantum World

When measuring, any state $|w\rangle = -|w\rangle$

We cannot detect an overall sign change

.

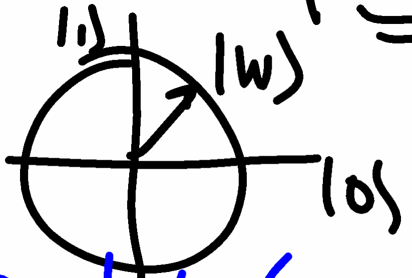
QUANTUM GATES & CIRCUITS

Q ———————— ≡ Identity Gate

atom w/ Qbit

For 1-classical bit ⇒ only 2 gates: · Identity
· NOT

For 1-Qbit ⇒ Infinite many gates

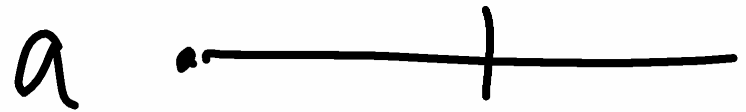


→ all rotations of $|\psi\rangle$

But all 1-Qbit gates can be built from only 4 gates

"Actual Q Comp use a limited set of Gates

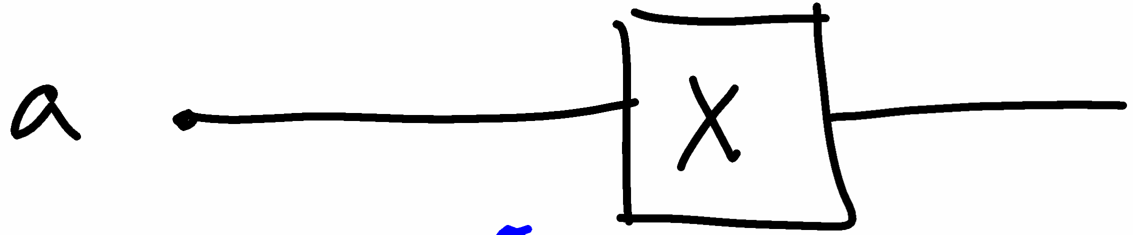
1-Qbit Gates



$\equiv$ Identity

$|0\rangle - \boxed{X} - |1\rangle$

$|1\rangle - \boxed{X} - |0\rangle$



Q-NOT

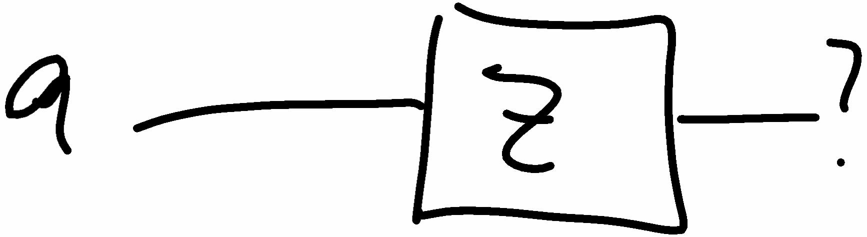
Using math we write this as

$X|0\rangle = |1\rangle$

$X|1\rangle = |0\rangle$

Notation similar to function notation

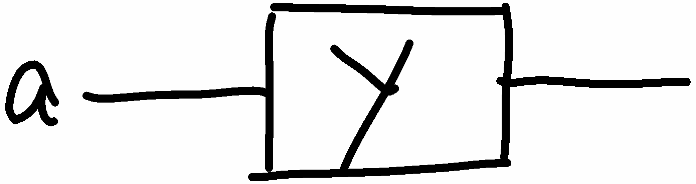
$f(0)=1 \iff X|0\rangle = |1\rangle$



$Z|0\rangle = |0\rangle$

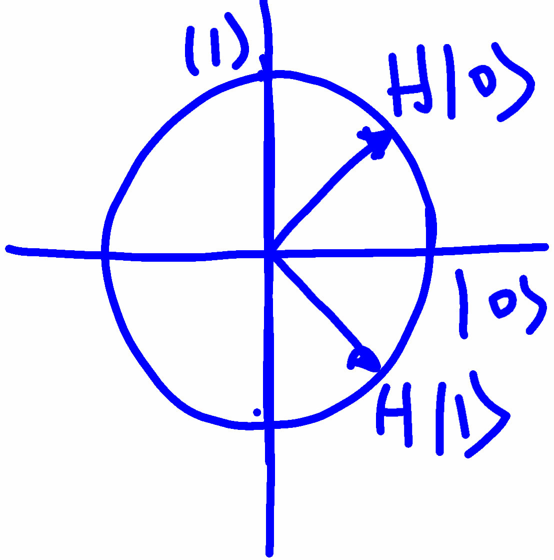
$Z|1\rangle = -|1\rangle$

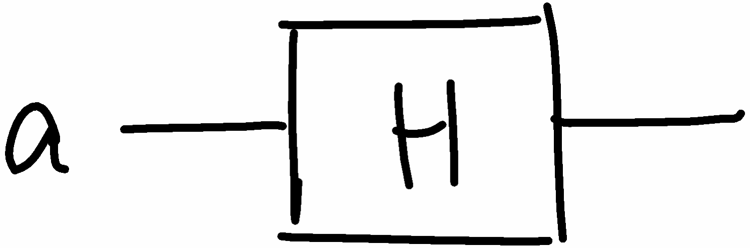
$$\left(i \equiv \sqrt{-1} \; ; \; i^2 = -1 \right)$$



$$|0\rangle = i\,|1\rangle$$

$$Y|1\rangle = -i\,|0\rangle$$





Hadamard

$$H|0\rangle = \frac{1}{\sqrt{2}}\left(|0\rangle + |1\rangle\right)$$

$$H|1\rangle = \frac{1}{\sqrt{2}}\left(|0\rangle - |1\rangle\right)$$

ENTANGLEMENT

Comes from "piling up" Qbits ⇒ Need 2 or more Qbits

- Independent "piling"

The state of the whole system

$|0\rangle$

$|1\rangle$

4 possibilities

$|0\rangle|0\rangle \; |1\rangle|1\rangle$

$|0\rangle|1\rangle \; |0\rangle|1\rangle$

$|00\rangle$

$|01\rangle$

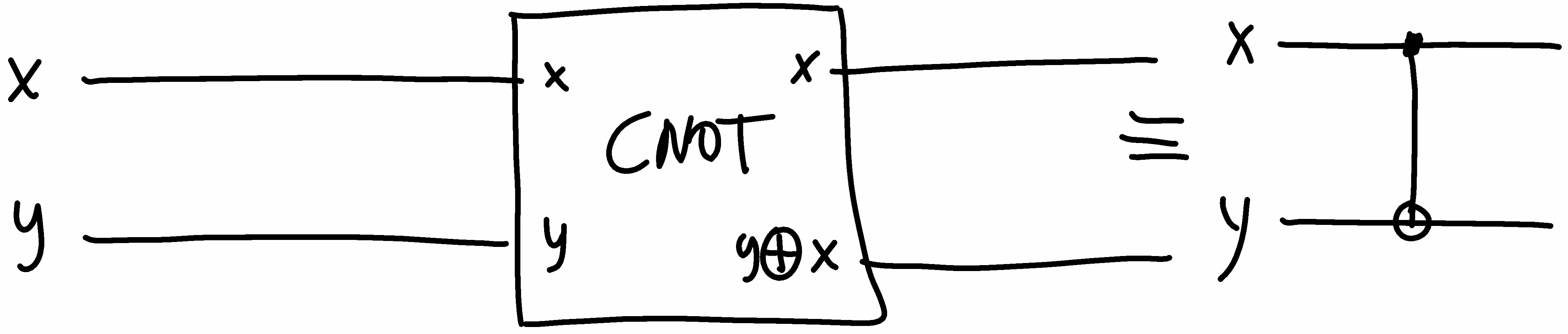
$|10\rangle$

$|11\rangle$

2 ways to write independent Qbits

$|1\rangle|0\rangle \equiv |10\rangle$

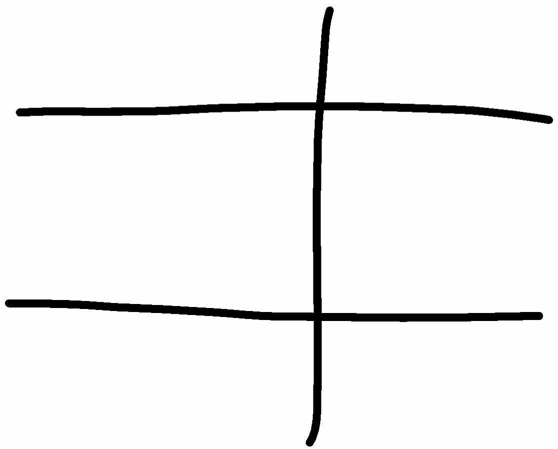
· ENTANGLED PAIR (NOT independent "piling")



$$|00\rangle \longrightarrow |00\rangle$$
$$|01\rangle \longrightarrow |11\rangle$$
$$|10\rangle \longrightarrow |10\rangle$$
$$|11\rangle \longrightarrow |01\rangle$$

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

$|1\rangle$



$$\frac{1}{\sqrt{2}}(|0\rangle + |1\rangle)|1\rangle = \frac{1}{\sqrt{2}}\left(|0\rangle|1\rangle + |1\rangle|1\rangle\right)$$

$$= \frac{1}{\sqrt{2}}\left(|01\rangle + |11\rangle\right)$$