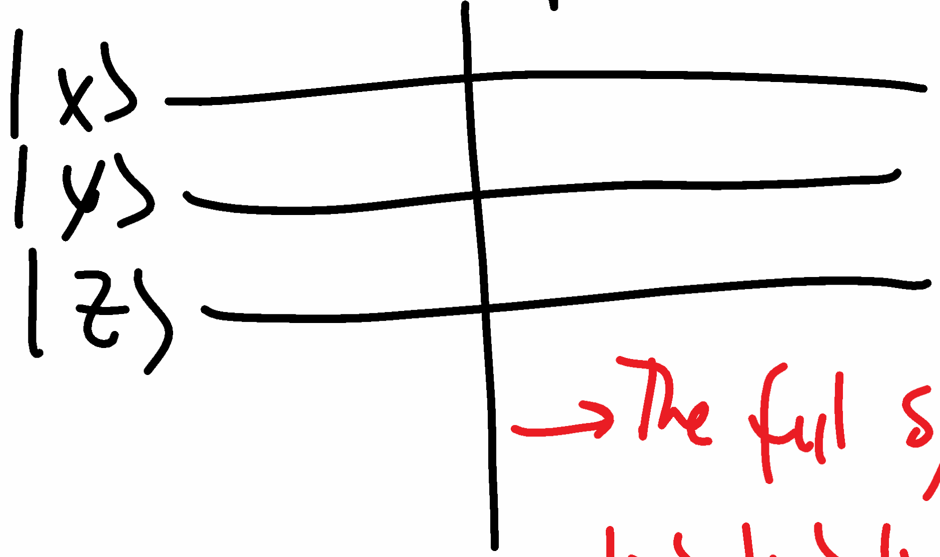
Entanglement (Cont.)

Wed 7 Nov 2018

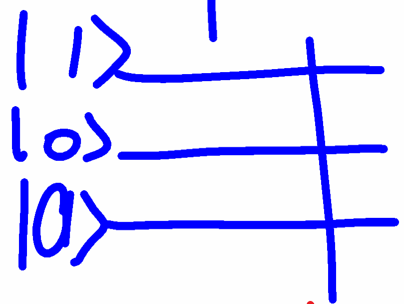
When we pile / stack qubits we represent this system by using multiple lines



→ The full system of 3 qubits

$$|z\rangle|y\rangle|x\rangle = |zyx\rangle$$

Example



1st qbit in in 1

3rd qbit in 1

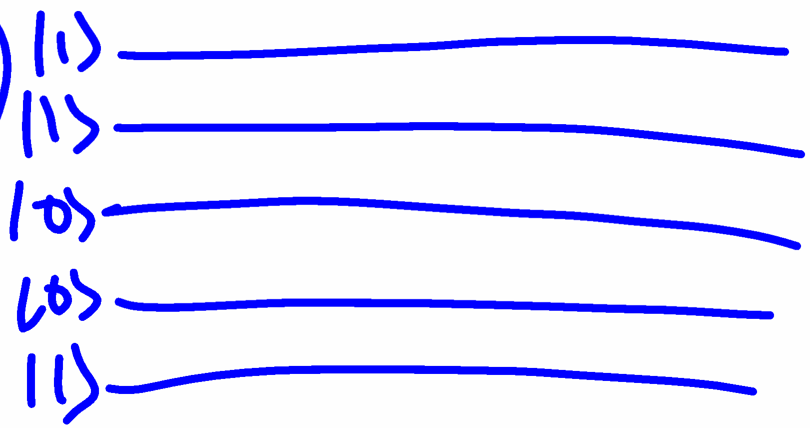
$$|001\rangle = |0\rangle|0\rangle|1\rangle$$

2nd qbit is in $|0\rangle$

Independent Qbits!!

<u>Exercise</u>: Write the diagram corresponding to the
a) state $|10011\rangle$
b) How many qubits do we have?
c) Are they all independent? Why?

<u>Sol</u>: a)



b) 5

c) Yes, because we can write the state as a product of individual qubits

$$|10011\rangle = |1\rangle|0\rangle|0\rangle|1\rangle|1\rangle$$

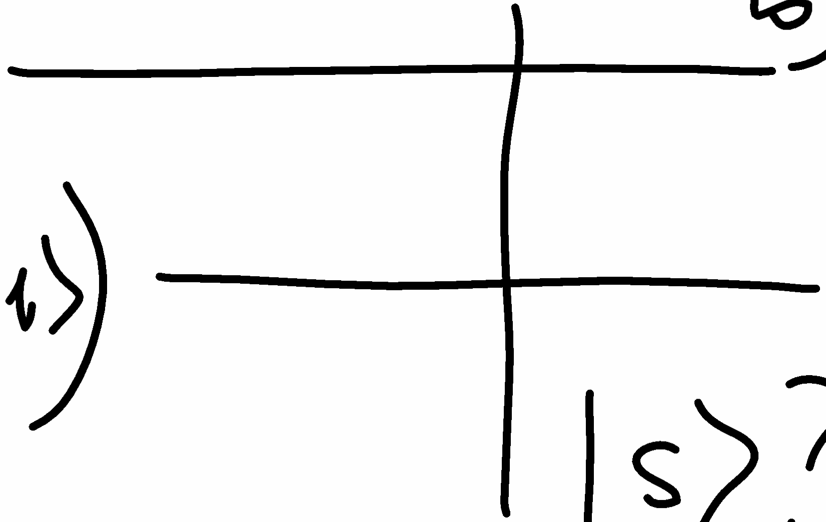
Exercise 2:

a) Write the state of this 2-qubit system.

b) Simplify & write it in terms of the fundamental states of this system. Hint: $|00\rangle$, $|01\rangle$, $|10\rangle$, $|11\rangle$

$|0\rangle$

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



$|s\rangle$?

Sol:

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

B: bottom qubit

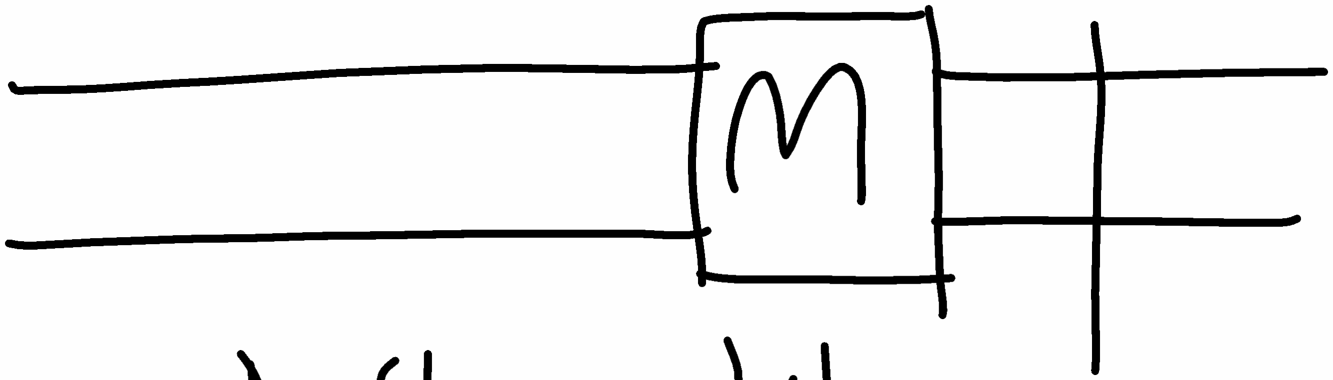
T: top qubit

b) $|s\rangle = \frac{1}{\sqrt{2}}\left(|0\rangle|0\rangle + |1\rangle|0\rangle\right) = \frac{1}{\sqrt{2}}\left(|00\rangle + |10\rangle\right)$

c) Are these qubits indep?

Yes, of course! 'cause $|s\rangle = |B\rangle\,|T\rangle$

Entangled Pair of Qubits



Are this qubits independent?

$$|S\rangle = \frac{1}{\sqrt{2}}\left(|00\rangle + |11\rangle\right)$$

Answer: In order to be independant it should be possible to write $|S\rangle$ as a product of 1 single qubit states $|B\rangle|T\rangle$

(cont)

ANSWER: THE ARE ENTANGLED that is not independent

1- Single qubit can be in many different states, e.g.

$$|0\rangle, \; |1\rangle, \; \frac{1}{\sqrt{2}}\left(|0\rangle + |1\rangle\right), \; \frac{1}{\sqrt{2}}\left(|0\rangle - |1\rangle\right), \; \ldots$$

Comment: In math this problem is similar to

$$7 + 5 = x\,y$$

Find x & y