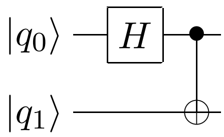
Submit your report by Friday, Feb. 10 (please provide screen captures where needed)

Can be written in groups of $\leqslant \dim(\mathcal{V}_2 \otimes \mathcal{V}_2)$ – indicate clearly your names on your work !

Exercise 1

Consider the following quantum circuit :



a) Starting from each of the initial basis states $|00\rangle$, $|01\rangle$, $|10\rangle$, $|11\rangle$, write the state of the qubits at each step.

b) Confirm your computations using the IBM Q circuit composer (you can easily prepare the qubits in any of the basis states starting from $|00\rangle$ and using X gates).

c) Write down the 4×4 matrix corresponding to this circuit and verify that it is unitary.

Exercise 2

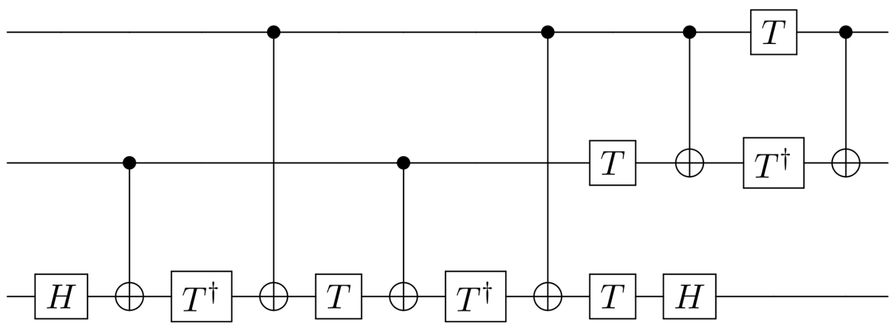
Come up with a 3-qubit circuit that implements U_f, where f is the boolean function

$$f(x, y) = x \,\mathrm{OR}\, y.$$

Verify your implementation on IBM Q.

Exercise 3

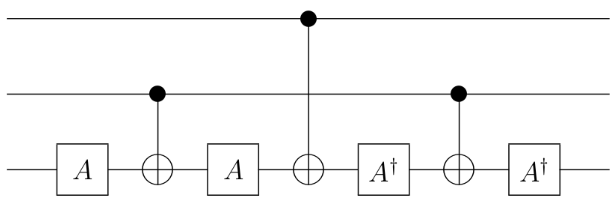
Consider the following assemblage U of quantum gates acting on 3 qubits :



a) Use the IBM Q *Vizualizations* tab to compute the effect of U on each of the 8 classical states of the system by preparing the 3 qubits accordingly each time.

b) Verify the above results by hand to make sure you understand what happens ; you should now have a matrix representation for U. Do you recognize this gate ?

c) The 3-qubit gate U is sometimes replaced by the following circuit V :



where $A = R_y(\frac{\pi}{4})$. By comparing the action of V and U on the qubits, discuss the advantages and inconvenients of using V in place of U.