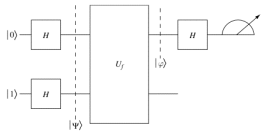
Evaluation Exercises
Quantum Computation

Integrated Master degree in Physics Engineering
2017-2018

Work description: Evaluation exercises worksheet

1. **Deutsch-Jozsa Algorithm**



   (a) Build an oracle for a balanced function with 3 qubits of input and one qubits of output

   (b) Draw the Deutsh-Jozsa circuit, for a system with two qubits of input and two qubits of output

   (c) Show all the calculations of the execution of the algorithm.

2. **Grover Algorithm**

   (a) **NP-complete problem**

   - Given a definition of a 3-SAT problem

$$(x_1 \vee x_2 \vee \neg x_3) \wedge (x_1 \vee x_2 \vee x_4)$$

   - Consider a search problem with 3 qubits, where $|110\rangle$ corresponds to the correct solution.
   - Create an oracle to decide a variable assignment
   - Build the entire circuit, using the oracle as a black box
   - Calculate the number of necessary iterations to obtain the optimal value for the iteration k in **this particular problem**.
     Hint: How many solutions satisfy the assignment? One or several?

$$G^K |\Psi\rangle = cos\frac{(2k+1)\theta}{2} |\alpha\rangle + sin\frac{(2k+1)\theta}{2} |y\rangle$$

3. **Hidden Subgroup problem**

x	1	2	3	4	5	6	7	8	9	10
f(x)	1	2	3	4	0	1	2	3	4	0

x	11	12	13	14	15	16	17	18	19	20
f(x)	1	2	3	4	0	1	2	3	4	0

Figure 1: Periodic function

(a) **Given the periodic function in figure 1, derived from a ciclic additive group**

- Identify:
  i. The cosets the function yeilds
  ii. The hidden subgroup
  iii. The subgroup generator
- Design a circuit for the quantum part
  i. What are the appropriate sizes for the registers ?
  ii. Define a possible oracle that mimics the function.
  iii. Define a circuit of a Fourier transform for this problem.
  iv. Design the whole circuit.