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**Student ID:**

# ELE523E Computational Nanoelectronics
# Homework 2

Deadline: 31/10/2016 (before the lecture)

## 1. MOLECULAR COMPUTING

**a)** Write a biochemical code to implement the following functions. Try to minimize the number of *different reaction rates*. For example, if you use "slow", "fast", and "fastest" then you use 3 different reaction rates.

- Decrement: $|y| = |x| - 1$
- Increment: : $|y| = |x| + 1$
- Polynomial: $|y| = 2|x|^2 + 3|x| + 1$
- Logarithmic**:** $|y| = log_2|x|$

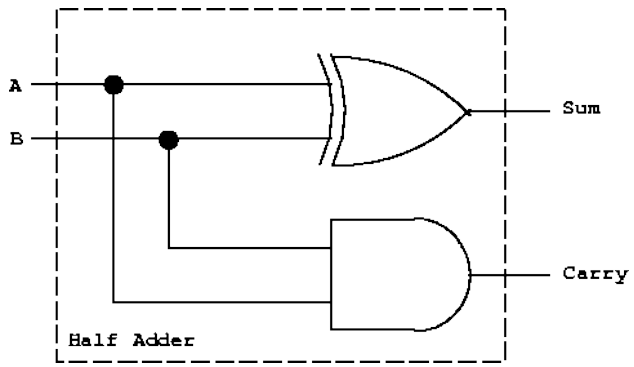
## 2. DNA STRAND DISPLACEMENT

For his part, use the Microsoft DNA Displacement Tool: http://research.microsoft.com/en-us/projects/dna/. Using an internet browser **FIREFOX**, download the program (MAIN). Then go through the "**TUTORIAL**" to learn how the tool works.

**a)** Write three different codes for Boolean gates **OR-2**, **OR-3**, and **XOR-2**. For demonstration, compile your codes and use "species" "reactions", and "graph" links in the tool.

- **Hint**: A similar example is given for an AND date under "examples" in the tool.

**b)** Implement the following **1-bit half adder circuit** with using the tool; write a code. Note that inputs (DNA strands) of the gates are same.




## 3. COMPUTING WITH NANO ARRAYS

**a)** Implement each of the following Boolean functions with **two-terminal diode-based**, **two-terminal CMOS-based**, and **four-terminal switch-based** nano arrays. Since there are 3 Boolean functions $f_1$, $f_2$, and $f_3$, you should have 9 implementations. You are allowed to directly use variables ($x$) and their negations ($\bar{x}$) as inputs. For each implementation, try to find the **minimum** array size in terms of the number of crosspoints; you should consider all crosspoints regardless of using/not using them in your implementation.

- $f_1 = x_1x_2x_3 + \overline{x_2}x_4$
- $f_2 = x_1x_2x_3 + x_1x_4 + x_2x_4$
- $f_3 = x_1\overline{x_2}x_3 + x_1\overline{x_4} + x_2x_3\overline{x_4}$

**b)** Which circuit type (diode, CMOS, or 4-terminal) gives you the **best result** in terms of the array size? Why? For each circuit type, derive an expression for array size. For example, an expression with the number of products, variables, and literals of corresponding Boolean functions.

*Grading: 1)30% - 7.5% each*
*2a)20%, 2b)15%,*
*3a)20%, 3b)15%*

Note: *Return a hard-copy of your homework before the lecture time at 13:30.*