# EECS 151/251A Homework 1

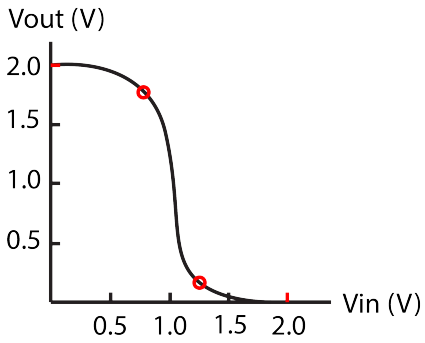
Due Friday, September 13th, 2019

## Problem 1: Dennard Scaling and Power [5 pts]

Imagine that we still live in the world of ideal Dennard scaling. You designed a brilliant laptop microprocessor that runs at 4GHz, but dissipates 20W. What would be its power and performance in the next technology node, with features that are scaled by a factor of 0.7?

## Problem 2: Noise Margins [5 pts]

Calculate $V_{OH}, V_{IH}, V_{OL}, V_{IL}$ and the noise margins for the VTC shown below. The red circles show roughly where the $slope = -1$.



## Problem 3: Voltage Transfer Curves [5 pts]

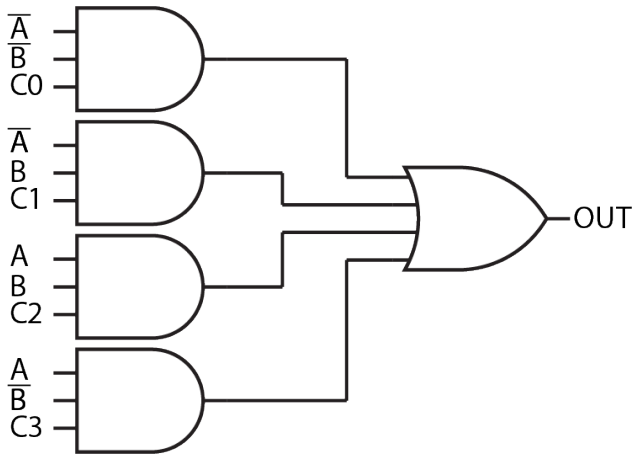
You're cleaning up your lab when you come across an interesting black box with two inputs (A and B), an output (Out) attached to a 2V power supply ($V_{DD} = 2V$). You are kind of curious so you try playing with it and you notice a few interesting things:

- If A and B are both $< 0.5$ volts for 5 microseconds or more, then the output will be greater than 1.5 volts.
- if A is $< 0.5$ volts, but B is $>1.5$ volts then the output is 1.5 volts.
- if B is $< 0.5$ volts, but A is $>1.5$ volts then the output is 1.5 volts.
- When both A and B are $>1.5$ volts for at least 5 microseconds, then the output will be $<0.2$ volts
- The output is always between 0 and 2 volts

Given this information, answer the following questions:

1. What logical function does the black box implement?
2. How could you use these black box to calculate the following functions:
   (a) Inversion (hint: consider shorting the inputs to a single signal, X)
   (b) And
   (c) Or
3. For the inverter case draw a very simple voltage transfer curve, making sure to label key voltages on both axes.
4. What is the propagation delay of a single black box in the "inverter" case?

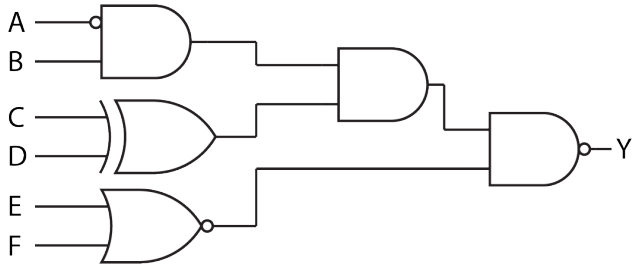
## Problem 4: Sum-of-Products [5 pts]



Consider the given circuit. All inputs (A, B, C0, C1, C2, and C3) must be tied to 0 or 1.

1. What must C0 thru C3 be such that F = XNOR(A, B)?
2. Can any arbitrary 2 input logic function of signals A and B be realized using the above architecture? Explain.

## Problem 5: Truth Tables and Product-of-Sums [5 pts]




1. Create a truth table for the given circuit.
2. Give a product-of-sums expression for the truth table and simplify.

## Problem 6: Boolean Algebra [5 pts]

Prove the following Boolean expressions:

1. $((\overline{A})(\overline{B}) + C)(A + B)\overline{(\overline{B} + AC)} = \overline{A}BC$
2. $(\overline{A})(\overline{B}) + AB + \overline{A}B = \overline{A} + B$
3. $\overline{A}(A + B) + (B + AA)(A + \overline{B}) = A + B$