

Massachusetts Institute of Technology
Department of Electrical Engineering and Computer Science

6.002 – Circuits and Electronics
Spring 2003

Handout S03-065 - Final Exam

Tuesday May 20, 2003

Name: _____

Recitation Instructor (circle one):

Baldo Hutchinson Kolodziejcki Schindall Wilson

Recitation Hour (circle one):

9 10 11 12 1 2

NOTE THAT PROBLEMS HAVE WEIGHTS RANGING FROM 10 TO 16

Problem	Points	Score	Grader
1	16		
2	10		
3	12		
4	12		
5	10		
6	12		
7	14		
8	14		
Total	100		

Name: _____

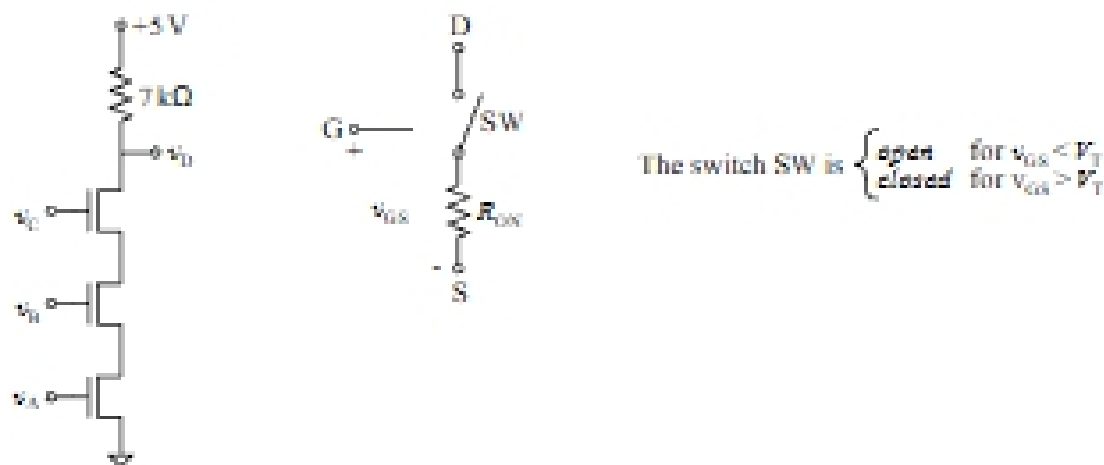
PROBLEM 1

Joe Nerdle, who took 6.002 some time ago, wants to assemble a *three-input AND gate*. He finds sufficient identical MOSFETS of *unknown specifications*.

The several parts below are independent.

- (A) In fifty words or less, describe measurements which Joe can make to determine the *threshold voltage* V_T and the *on resistance* R_{ON} of the FETs. Include a circuit diagram if you wish.

Joe establishes a static discipline in which a logical one corresponds to $v > 4$ volts and a logical zero corresponds to $v < 1$ volt. A three input *NAND* gate and the switch-resistor model for the FET are shown below:



- (B) Write a Boolean expression which describes the logical function of this gate.

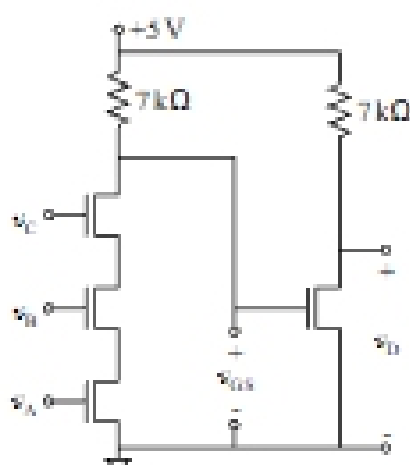
Name: _____

For the remaining parts of this problem, use these values:

$$R_{ON} = 1\text{k}\Omega, V_T = 1\text{V}$$

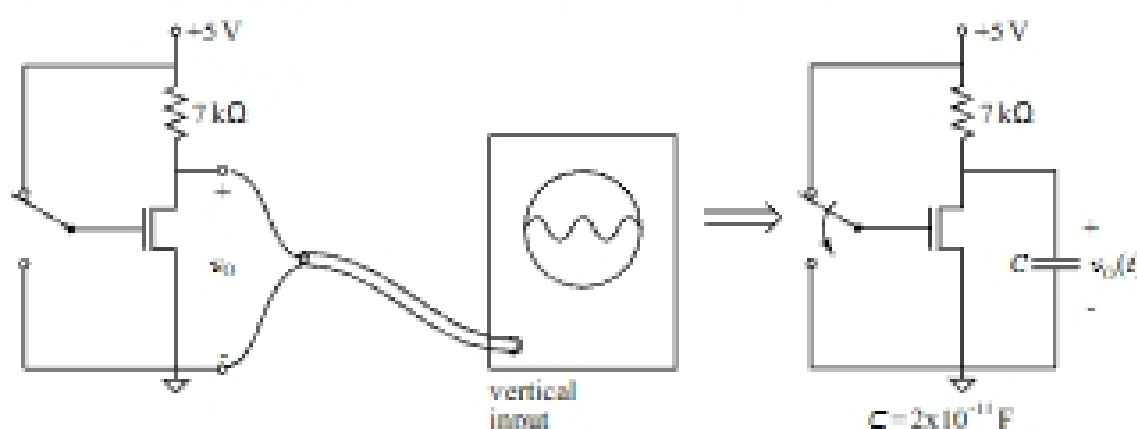
(C) When $v_A = v_B = v_C = 5\text{V}$, determine v_D .

(D) Because Joe wants an *AND* gate, he connects the output of the gate above to a FET inverter as shown below:



When he builds this circuit he finds that v_D is low for all input conditions. *Explain.*

(E) In an effort to understand the reason the *AND* gate does not work, Joe isolates the inverter and connects an oscilloscope to its output as shown below.



He can't find a scope probe so he uses a long piece of coaxial cable. This unfortunate arrangement provides a capacitive load of $C = 20\text{pF} = 2 \times 10^{-11}\text{F}$ to the inverter. The resulting circuit is the one shown above right.

Sketch and label the waveform $v_O(t)$ which Joe sees on the scope when the switch changes the input voltage from $+5\text{V}$ to 0V at $t = 0$. Also sketch and label the waveform $v_O(t)$ which Joe sees on the scope much later ($t > 5\tau$) when the switch changes the input voltage from 0V to $+5\text{V}$ at $t' = 0$. Show asymptotes and determine the time constant. Use the coordinates provided on page 4.