Name:

PUID:

ECE 559
Exam 2

Time : 1 Hr 10 Mins

Total Points :100

There are 6 pages in this exam booklet.

It is a closed book closed notes exam. No calculators permitted.

State clearly any assumptions you make.

Question 1:

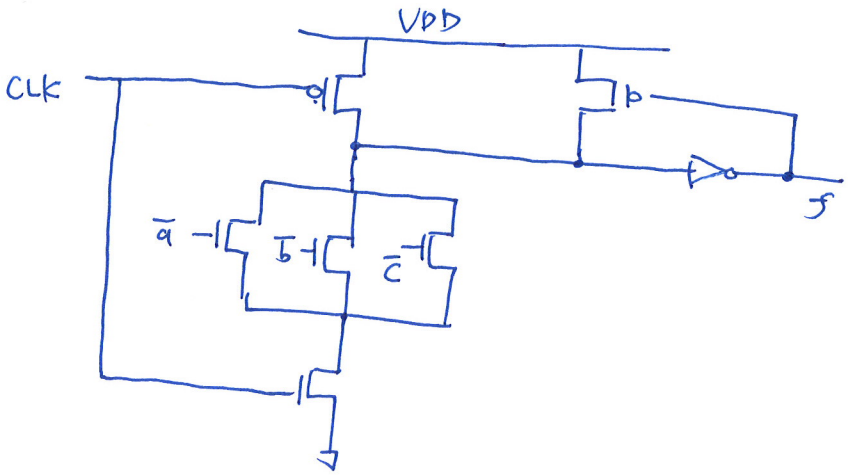
(a) Draw a schematic of a 3-input NAND gate implemented using domino logic with a PMOS keeper. Clearly label the input and output signals in your schematic.

(15 points)

Input : a, b, c

$f = \overline{abc}$

$\bar{f} = \overline{\overline{abc}} = \overline{\bar{a} + \bar{b} + \bar{c}}$



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(b) Suppose the three inputs in the schematic in part (a) have signal probabilities 5/8, 1/2 and 2/5 respectively. Determine the probability of switching for the output node, neglecting spatial and temporal correlation between the signals.

(15 Points)

Output switching happens

when $a=0$ or $b=0$ or $c=0$

$\therefore P = 1 - P(a=1)\,P(b=1)\,P(c=1)$

$= 1 - \frac{5}{8} \times \frac{1}{2} \times \frac{2}{5} = \frac{7}{8}$

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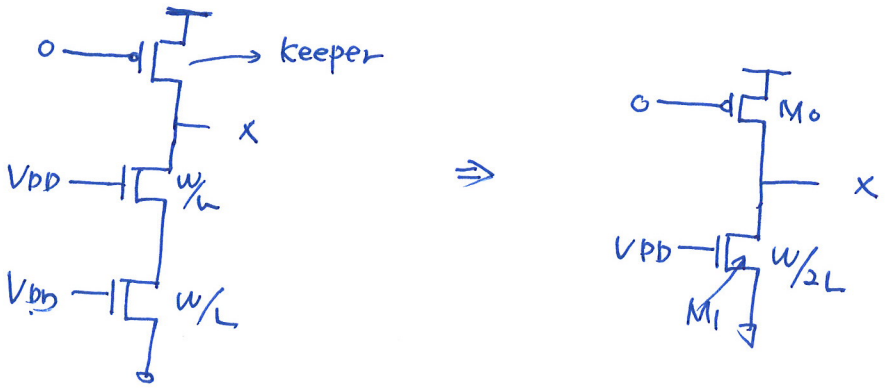
(c) Suppose all the NMOS transistors in your schematic of part (a) have W/L = 2. The output inverter has the logic threshold voltage (V_M) = $V_{dd}/2$. If k_N = 2 mA/V^2, k_p = 1 mA/V^2, V_{tn} = 1V, V_{tp} = -1V and V_{dd} = 5V, determine W/L for the keeper that ensures correct functionality of the circuit.

(40 points)

(*Hints: To ensure correct functionality, worst case should be considered.*
It may be easier to solve the problem by breaking the keeper feedback.)

1. The ~~this~~ worst case : only one Nmos turns on
2. Feedback need to be broken.



~~X~~ For correct functionality, $V_x \leq V_M = \frac{V_{DD}}{2}$

When $V_x = \frac{V_{DD}}{2}$,

for M_0, $V_{gs} = -V_{DD}$, $V_{DS} = -\frac{V_{DD}}{2}$ ⇒ linear

for M_1, $V_{gs} = V_{DD}$, $V_{DS} = \frac{V_{DD}}{2}$ ⇒ linear ($\because V_{tp} = -1$)

$$I_{M_0} = k_p \left(\frac{W}{L}\right)_p \left[(5-1)\times 2.5 - 2.5^2\right]$$

$$\leq I_{M_1} = k_n \left(\frac{W}{2L}\right)_n \times \left[(5-1)\times 2.5 - 2.5^2\right]$$

$$\therefore \left(\frac{W}{L}\right)_p \leq \frac{k_n}{k_p} = 2$$

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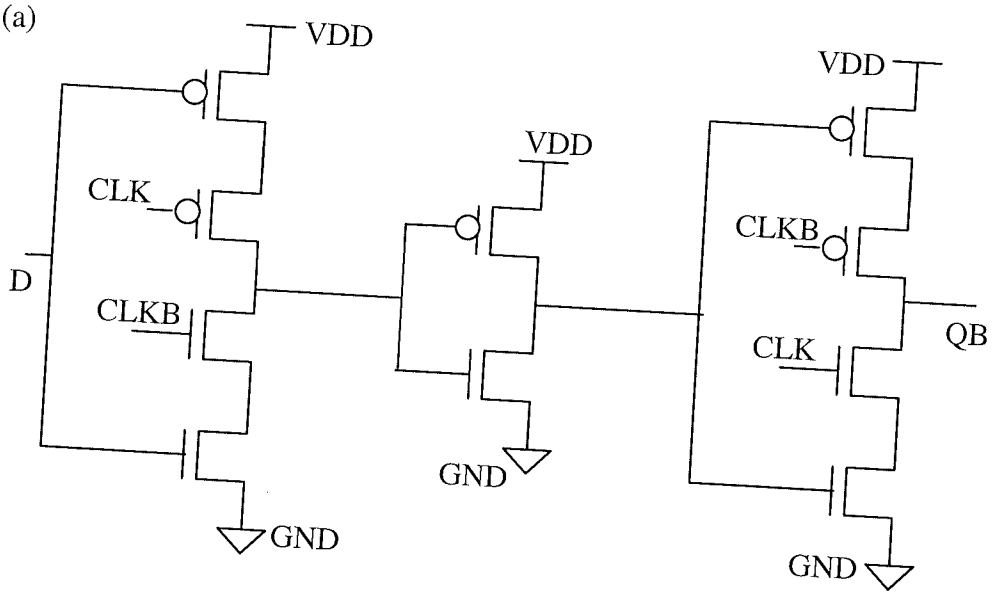
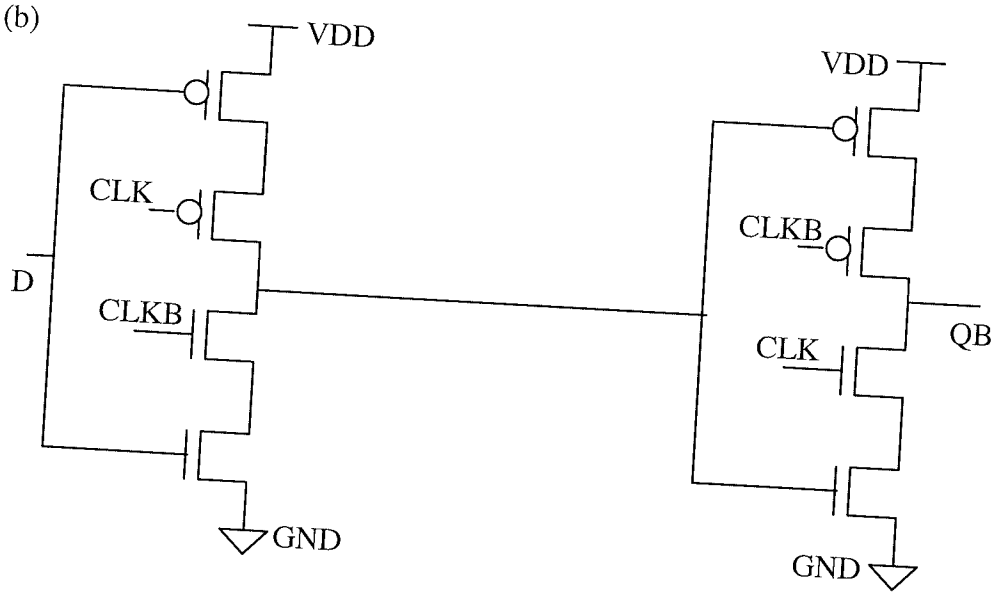
Question 2:
For each of the circuits given below, determine if race condition exists in case of 0-0 overlap. Clearly explain your reasoning.

(a) (30 Points)



(b)



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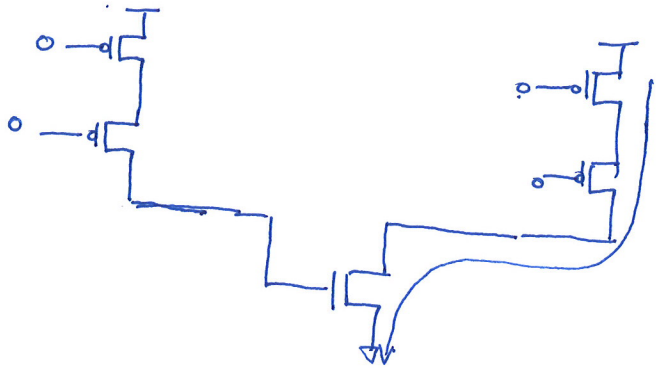
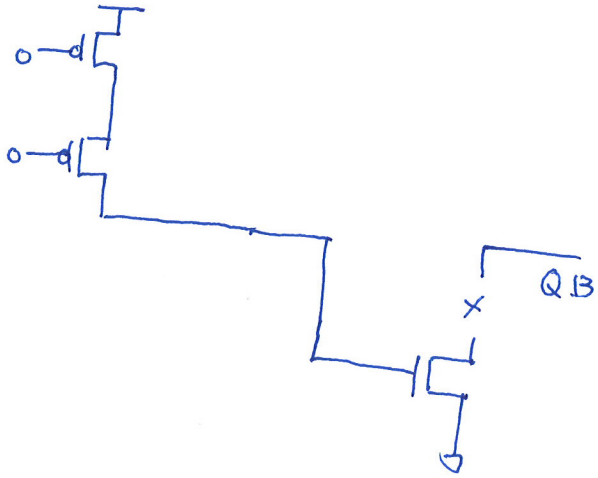
(a)

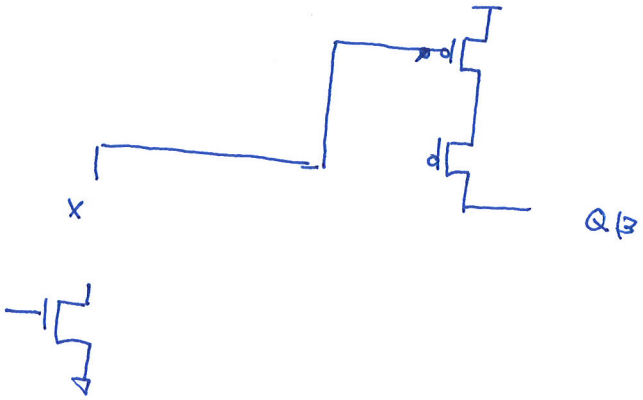


race condition

(b)



No race condition



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