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Date: 21/03/2022

EHB322E Digital Electronic Circuits
QUIZ I

Duration: 60 Minutes

Grading: 1) 50%, 2) 50%

For your answers please use the space provided in the exam sheet

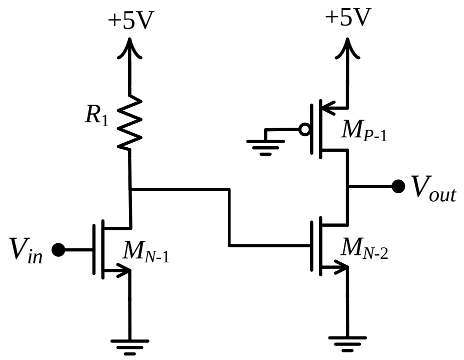
GOOD LUCK!

1) Consider a buffer shown below. Use the following equations for your calculations.

Saturation region current-voltage equation: $I_D = \frac{1}{2} k'_{p,n} \frac{W}{L} (V_{GS} - V_{T0\,p,n})^2$

Linear region current-voltage equation: $I_D = \frac{1}{2} k'_{p,n} \frac{W}{L} \left[2(V_{GS} - V_{T0\,p,n})V_{DS} - V_{DS}^2 \right]$

Transistor parameters: $k_p' = \mu_p c_{ox}$=54uA/V^2, $k_n' = \mu_n c_{ox}$=96uA/V^2, V_{TN}=1V, V_{TP}=-1V, $W_{N\text{-}1}$= $W_{N\text{-}2}$=12u, L_P=L_N=1u.



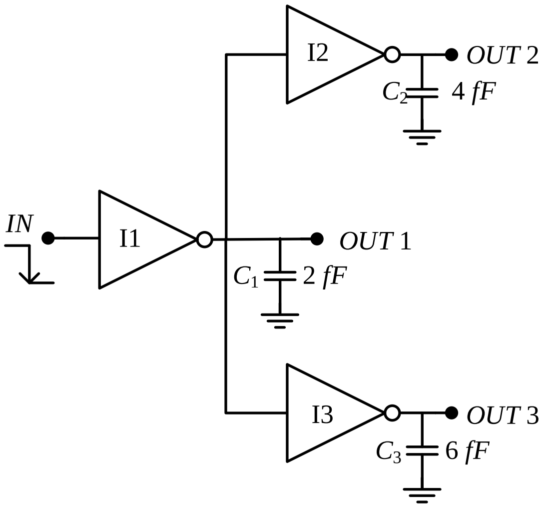
Buffer

a) Find the minimum value of $\boldsymbol{R_1}$ if $\boldsymbol{V_{in}}$**=5V** results in $\boldsymbol{V_{out}}$**= 5V**.

b) Find the value of $\mathbf{W_{P\text{-}1}}$ if $\boldsymbol{V_{in}}$**=0V** results in $\boldsymbol{V_{out}}$**= 0.5V**.

c) Find the buffer's static power consumption values when $\boldsymbol{V_{in}}$**=0V** and $\boldsymbol{V_{in}}$**=5V.**

2) Consider a circuit with three CMOS inverters and three outputs shown below. External capacitors with values of 2*fF*, 4*fF*,and 6*fF* are connected to output-1, output-2, and output-3, respectively. A signal switching from high to low is applied to the input.
Transistor parameters: c_{ox}=1 *fF*/um^2, τ_n= τ_p=1ps, W_{N1}=2u, W_{P1}=4u, W_{N2}=2u, W_{P2}=6u, W_{N3}=1u, W_{P3}=4u, and L_{N1}=L_{P1}= L_{N2}= L_{P2}= L_{N3}= L_{P3}=1u.



Digital circuit with three CMOS inverters

Propagation delays of an inverter are formulized as follows. C_L represents the total (internal and external) load capacitor of an inverter.

$t_{PHL} = (C_L/C_N)\ \tau_n$ $\qquad$ $C_N = c_{ox} W_N L_N$

$t_{PLH} = (C_L/C_P)\ \tau_p$ $\qquad$ $C_P = c_{ox} W_P L_P$

a) Neglect the inverters' internal output capacitors and find **total propagation delay values** at output-1 (delay of I1), output-2 (delay of I1+delay of I2), and output-3 (delay of I1+delay of I2).

b) Suppose that each inverter has an input internal capacitor $C_{I\text{-}in}$= c_{ox}(W_N+W_P)(1um) and an output internal capacitor $C_{I\text{-}out}$= c_{ox}(W_N+W_P)(0.5um). Find **total propagation delay values** (by considering both internal and external capacitors) at output-1, output-2, and output-3.