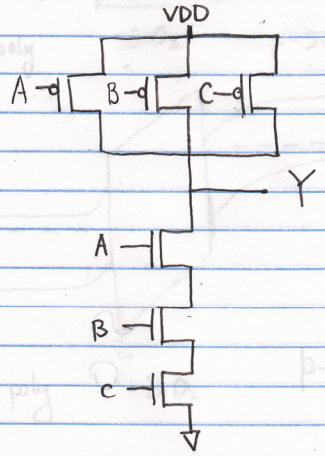
1)

HW 8
Solutions

① Design of 3 input NAND:

PUN → $Y = \overline{A \cdot B \cdot C} = \bar{A} + \bar{B} + \bar{C}$

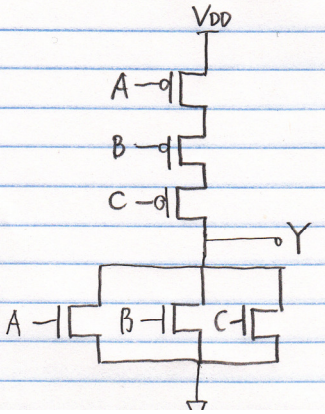
PDN → $\bar{Y} = A \cdot B \cdot C$



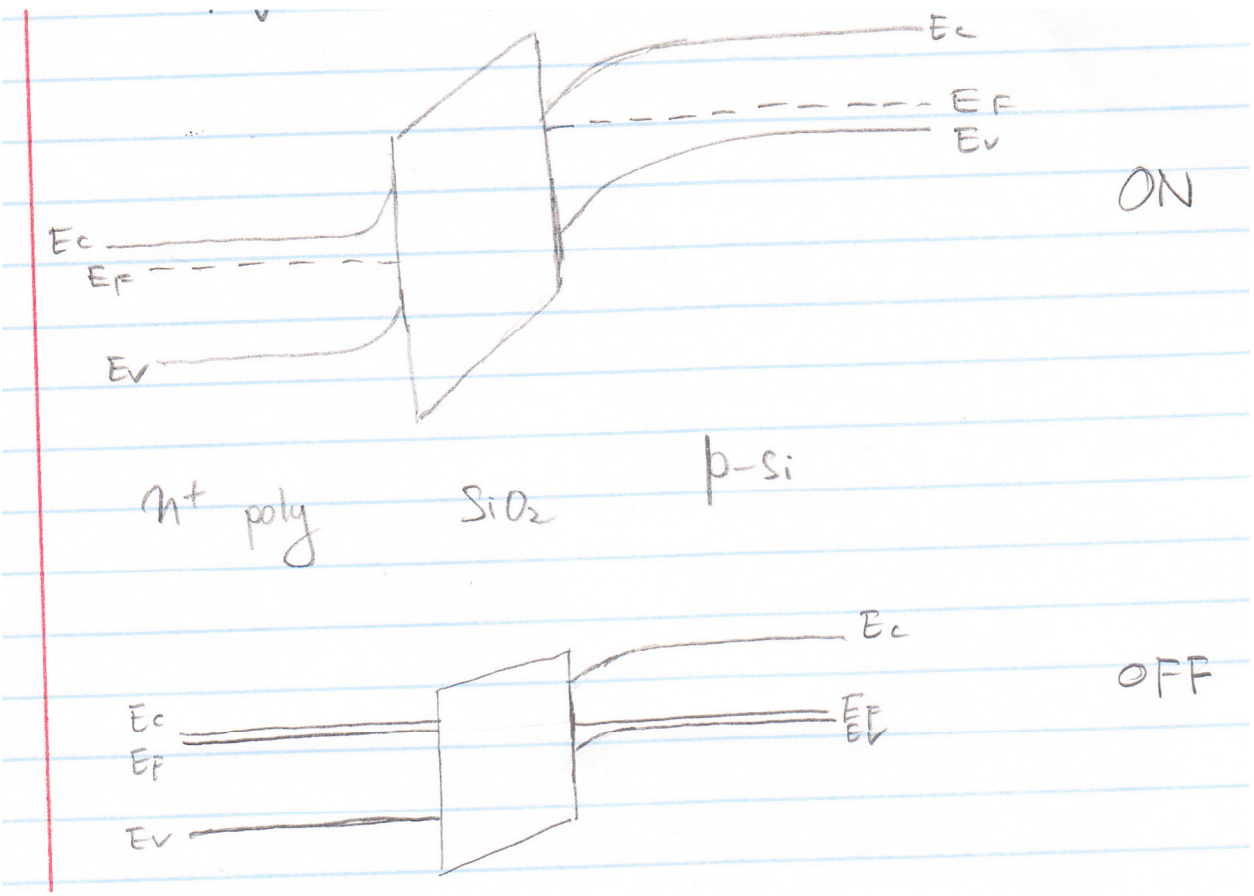
Design of 3 input NOR:

PUN → $Y = \overline{A+B+C} = \bar{A} \cdot \bar{B} \cdot \bar{C}$

$\bar{Y} = A+B+C$



2)



3)

(3) $\langle Q_{ox} \rangle = q\,10^{12}/cm^2 \quad x_o = 100nm$

$\sigma_{Qox} = 0.1 \langle Q_{ox} \rangle$

$\Delta V_T = \frac{Q_{ox}}{C_o} \qquad C_o = \frac{K_o \varepsilon_o}{x_o} = \frac{3.9 \times 8.854 \times 10^{-12} F/m}{100 \times 10^{-9} m}$

$= 3.453 \times 10^{8} pF/m^2$

$\Delta V_T = \frac{q \cdot 10^{12} \cdot 10^{4}\ m^{-2}}{3.453 \times 10^{-4} F/m^2} = 4.64V$

$\sigma_{V_T} = \frac{\Delta V_T}{10} = 0.464\,V$

Using Gaussian function:

$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$

Number of device > 1V threshold:

$\frac{10^9}{0.464\sqrt{2\pi}} \int_{1V}^{\infty} e^{\frac{(x-4.64)^2}{2(0.464)^2}} dx$

$\approx 10^9$ devices.

4)

④ DRAM $I_{leak} = 10fA$ $V_{dd} = 1V$ $C = 10pF$

$$t = \frac{Q}{2 \cdot I_{leak}} = \frac{V_{dd} \cdot C}{2 I_{leak}} = \frac{10^{-12}}{2 \cdot 10^{-15}} = 500s$$

Memory needs to be refreshed every 500s.