Synthesis of CMOS Gates

Let's consider the design synthesis of CMOS gates by considering the design synthesis of PUN and PDN separately.

**PDN Design Synthesis**

1. If the PDN is **conducting**, then the **output** will be **low**. Thus, we must find a Boolean expression for the **complemented output** $\bar{Y}$.

In turn, the PDN can only be conducting if **one or more** of the NMOS devices are **conducting**—and NMOS devices will be conducting (i.e., **triode** mode) when the inputs are **high** ($V_{GSN} = V_{DD}$).

Thus, we must express $\bar{Y}$ in terms of **un-complemented inputs** $A, B, C$, etc (i.e., $\bar{Y} = f (A, B, C)$).

   \[
   \text{e.g., } \Rightarrow \bar{Y} = A + BC
   \]

This step may test our **Boolean algebraic** skills!
2. Then, we realize **AND** operations in $\bar{Y} = f(A, B, C)$ with **series NMOS** devices. E.G.:

Note that $Y=0$ if both $A = V_{DD}$ AND $B = V_{DD}$.

3. Likewise, we realize **OR** operations with **parallel NMOS** devices. E.G.:

Note that $Y=0$ if either $A = V_{DD}$ OR $B = V_{DD}$.
**PUN Design Synthesis**

1. If the PUN is conducting, then the output will be high. Thus, we must find a Boolean expression for the un-complemented output \( Y \).

   In turn, the PUN can only be conducting if one or more of the PMOS devices are conducting—and PMOS devices will be conducting (i.e., triode mode) when the inputs are low (\( V_{GSP} = -V_{DD} \)).

   Thus, we must express \( Y \) in terms of complemented inputs \( \overline{A}, \overline{B}, \overline{C} \), etc (i.e., \( Y = f(\overline{A}, \overline{B}, \overline{C}) \)).

   \[
   \text{e.g., } \quad Y = \overline{A} + \overline{B} \overline{C}
   \]

   This step may test our **Boolean algebraic skills**!
2. Then, we realize **AND** operations with **series PMOS** devices. E.G.:

Note that $Y = V_{DD}$ if both $A = 0$ **AND** $B = 0$. 

$Y = \overline{A} \overline{B}$

3. Likewise, we realize **OR** operations with **parallel PMOS** devices. E.G.:

Note that $Y = V_{DD}$ if either $A = 0$ **OR** $B = 0$. 

$Y = \overline{A} + \overline{B}$