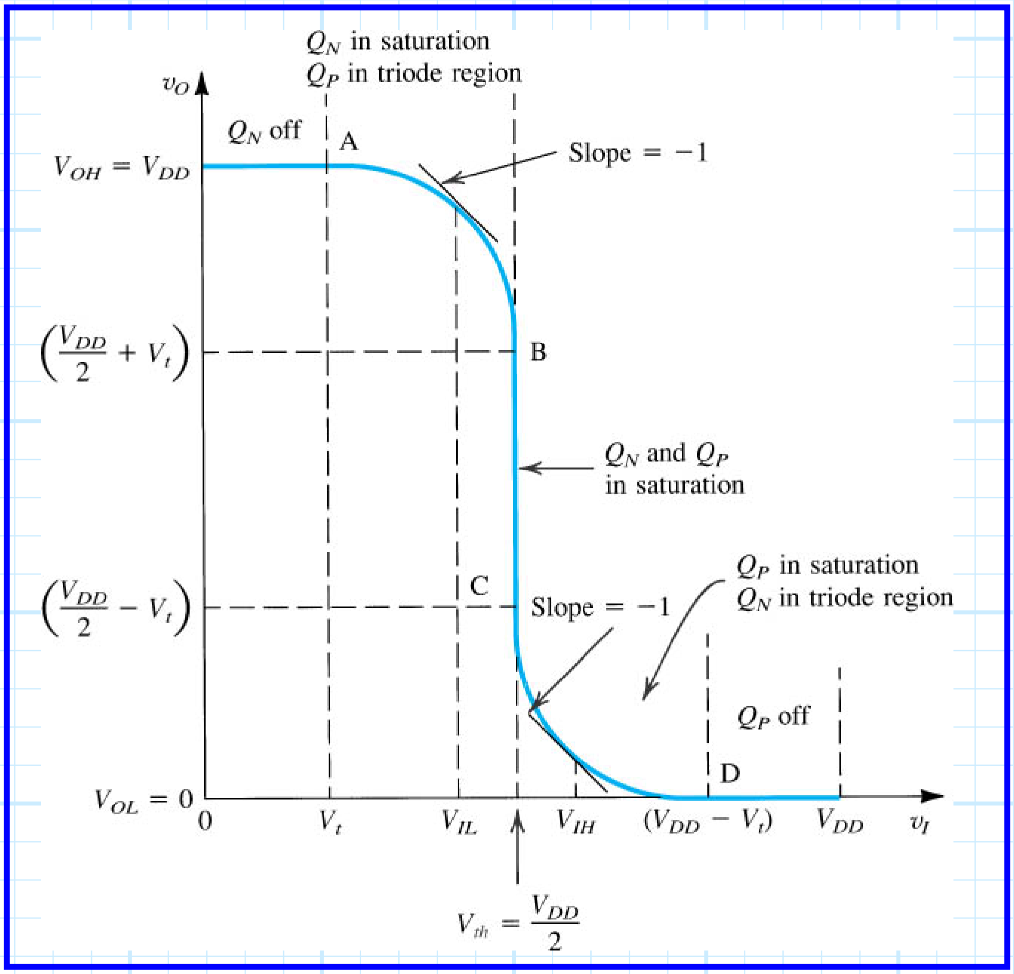
The CMOS Transfer Function

Now, instead of determining the output v_O of a CMOS inverter for just **two specific** input voltages ($v_I = 0$ and $v_I = V_{DD}$), we can determine the value of v_O for **any** and **all** input voltages v_I—in other words, we can determine the **CMOS inverter transfer function** $v_O = f(v_I)$!

Determining this transfer function is a bit laborious, so we will simply present the result (the **details** are in you **book**):



Look at how close **this** transfer function is to the **ideal** transfer function!

The **transition region** for this transfer function is very **small**; note that:

1. V_{IL} is just a bit **less** than $V_{DD}/2$

2. V_{IH} is just a bit **more** than $V_{DD}/2$

In fact, by taking the **derivative** of the transfer function, we can determine the **two points** on the transfer function (i.e., V_{IL} and V_{IH}) where the **slope** is equal to –1.0. I.E. :

$$v_I \text{ where } \frac{dv_O}{dv_I} = -1.0$$

Taking this derivative and **solving** for v_I, we can determine **explicit** values for V_{IL} and V_{IH} (again, the **details** are in your **book**):

$$V_{IL} = \frac{1}{8}\left(3V_{DD} + 2V_t\right)$$

$$V_{IH} = \frac{1}{8}\left(5V_{DD} - 2V_t\right)$$

Now, recall earlier we determined that the CMOS inverter provides **ideal** values for V_{OL} and V_{OH}:

$$V_{OL} = 0.0$$

$$V_{OH} = V_{DD}$$

Thus, we can determine the **noise margins** of a CMOS inverter:

$$\begin{aligned} NM_L &= V_{IL} - V_{OL} \\ &= \frac{1}{8}(3V_{DD} + 2V_t) - 0.0 \\ &= \frac{1}{8}(3V_{DD} + 2V_t) \end{aligned}$$

and:

$$\begin{aligned} NM_H &= V_{OH} - V_{IH} \\ &= V_{DD} - \frac{1}{8}(5V_{DD} - 2V_t) \\ &= \frac{1}{8}(3V_{DD} + 2V_t) \end{aligned}$$

Therefore, the two noise margins are **equal**, and thus we can say that the noise margin for a **CMOS inverter** is:

$$NM_L = NM_H = \frac{1}{8}(3V_{DD} + 2V_t)$$