1 CMOS Inverter Amplifier

Figure 1 shows a CMOS inverter biased as a linear amplifier. For this problem, use the transistor parameters in Table 1.

Parameter	NMOS	PMOS
V_t	1 V	-1 V
L_d	0	0
X_d	0	0
k'	300 μA/V^2	100 μA/V^2
γ	0	0
W/L	2	6
λ	0.1 V^{-1}	0.1 V^{-1}

Table 1: Problem 1 Transistor Parameters.

Problem 1.1 (3 points) Assume $V_I = 1.5$ V. For what range of V_O will the circuit best act as an amplifier? What is the output voltage swing?

Want M1 + M2 in saturation:

$V_{GS1} = V_I = 1.5\,V$, $V_{OV1} = 0.5\,V \Rightarrow V_{out} \geq 0.5\,V$

$V_{GS2} = V_{DD} - V_I = 1.5\,V$, $V_{OV2} = 0.5\,V \Rightarrow V_{out} \leq 2.5\,V$

$0.5\,V \leq V_{out} \leq 2.5\,V$

Output swing = 2V as amplifier
= 3V ($0 \leq V_o \leq V_{DD}$) for output levels

Problem 1.2 (2 points) Find the power dissipation assuming the bias conditions in Problem 1.1.

$$I_{D1} = I_{D2} = \frac{k_n'}{2}\left(\frac{W}{L}\right)_n (V_I - V_{tn})^2 = \frac{300\,\mu A/V^2}{2}(2)(1.5\,V - 1)^2$$

$= 75\,\mu A$ ($86.2\,\mu A$ if $\lambda = 0.1\,V^{-1}$, $V_{DS} = 1.5\,V$)

$P = I_{D1} V_{DD} = 225\,\mu W$