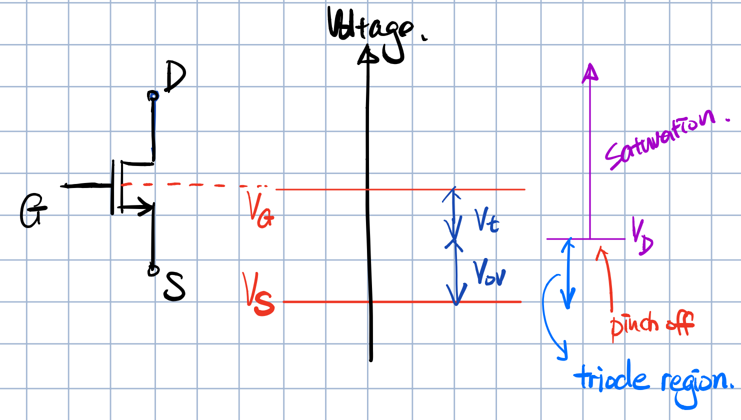
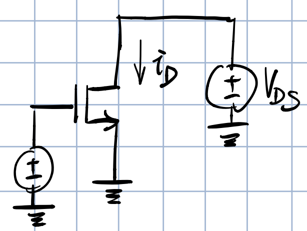


Example. $\frac{W}{L} = \frac{8\mu m}{0.8\mu m}$, $C_{ox} = 4.32 \times 10^{-3}\ F/m^2$, $\mu_n = 450 cm^2/Vs$

$k_n' = \mu_n C_{ox} = 194 \mu A/V^2$ ∴ it's n-type. $V_t = 0.7V$

a) Find V_{GS} and $V_{DS_{min}}$ to operate in saturation. w/ $i_D = 100\mu A$.



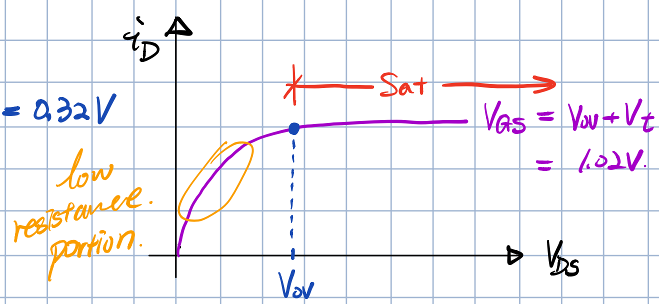
$$i_D = \frac{1}{2} k_n' \left(\frac{W}{L}\right) V_{ov}^2 = \frac{1}{2} k_n' \left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

i_D = $100\mu A$ ✓ ✓ $V_{GS} = 1.02V$

$V_{ov} = V_{GS} - V_t = 1.02 - 0.7 = 0.32V$

$\parallel$

V_{DS} minimum.

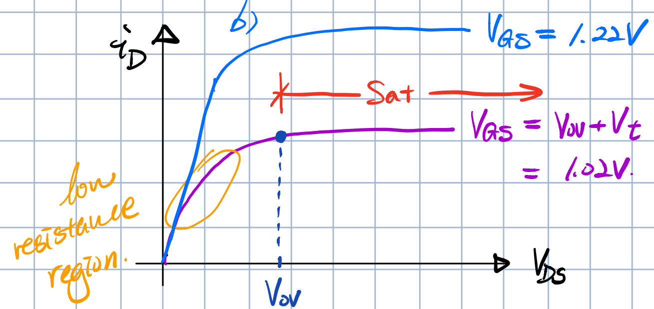


b) Find V_{GS} to achieve a resistance of $1k\Omega$ for small V_{DS}

$$r_{DS} \doteq \frac{1}{k_n' \left(\frac{W}{L}\right) V_{ov}} = 1k\Omega$$

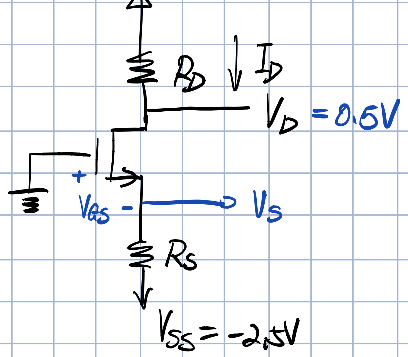
→ solve for. $V_{ov} = 0.515V$

$$V_{GS} = V_{ov} + V_t = 0.515 + 0.7 = 1.22V$$



Example 2. (design) $V_t = 0.7V$, $\mu_n C_{ox} = 100\mu A/V^2$, $L = 1\mu m$, $W = 32\mu m$

$V_{DD} = 2.5V$

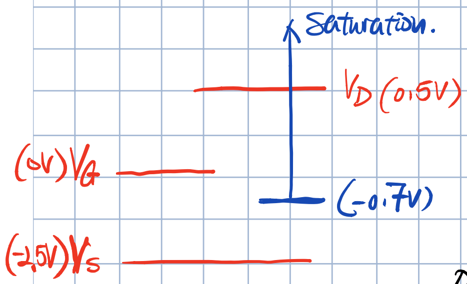


find R_D and R_S, so that $I_D = 0.4mA$, $V_D = 0.5V$

$\longrightarrow$ trans. is in saturation ($V_D > V_G$)
见最上面的图.

$$R_D = \frac{V_{DD} - V_D}{I_D} = \frac{2.5 - 0.5}{0.4mA} = 5k\Omega.$$

Calculate V_{GS}.



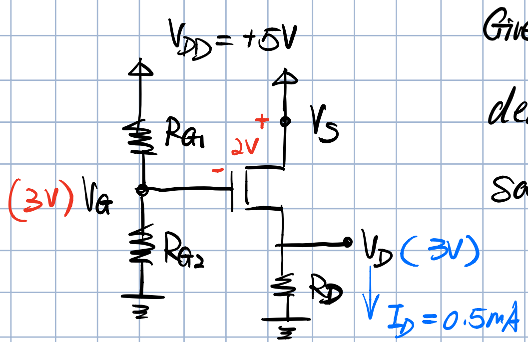
$$I_D = \frac{1}{2} k_n' \left(\frac{W}{L}\right)(V_{GS} - V_t)^2$$

0.4mA ✓ ✓ 0.7V $\longrightarrow$ solve for $V_{GS} = 1.2V$

$$V_S = V_G - V_{GS} = 0 - 1.2 = -1.2V$$

$$R_S = (V_S - V_{SS})/I_D = \frac{-1.2 - (-2.5)}{0.4} = 3.25k\Omega$$

Example 3 (PMOS)



Given $V_{tp} = -1V$, $k_p' \left(\frac{W}{L}\right) = 1mA/V^2$

design to have the trans. operate in saturation $I_D = 0.5mA$ and $V_D = 3V$

a) R_D, R_{G1} & R_{G2}

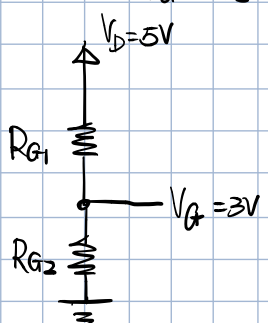
b) What is the largest value of R_D while keeping the transistor in saturation.

a) $R_D = V_D / I_D = 3V / 0.5mA = 6k\Omega$.

$I_D = \frac{1}{2} k_p' \left(\frac{W}{L}\right) V_{ov}^2$, solve $|V_{ov}| = 1V$

$V_{SG} = |V_{ov}| + |V_{tp}| = 1 + 1 = 2V$

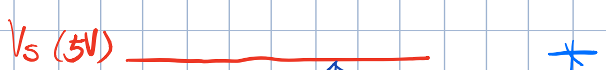
$V_G = V_S - 2V = 5V - 2V = 3V$

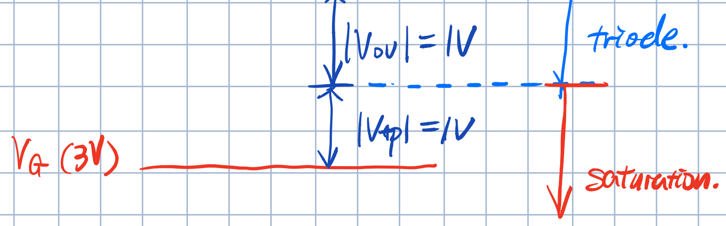


$$\frac{R_{G2}}{R_{G1} + R_{G2}} \cdot 5V = 3V$$

$$\frac{R_{G2}}{R_{G1} + R_{G2}} = \frac{3}{5}$$

pick $R_{G1} = 2M\Omega$ $R_{G2} = 3M\Omega$.





b) $V_{Dmax} = V_S - |V_{ov}| = 5-1 = 4V$

$$R_{Dmax} = \frac{V_{Dmax}}{I_D} = \frac{4V}{0.5mA} = 8k\Omega.$$