EX (5.1) Page (257)

$L = 0.18\ \mu m$ $\quad t_{ox} = 4\ nm$ $\quad \mu_n = 450\ cm^2/V$

$V_t = 0.5\ V$ $\quad \epsilon_{ox} = 3.45 \times 10^{-11}\ F/m$

a) find: C_{ox} and $k_n' \rightarrow$ Process transconductance Parameter

- $C_{ox} = \dfrac{\epsilon_{ox}}{t_{ox}} = \dfrac{3.45 \times 10^{-11}}{4 \times 10^{-9}} = \boxed{8.63 \times 10^{-3}\ F/m^2}$

- $k_n' = \mu_n C_{ox} = 450 \times 10^{-4}\ (8.63 \times 10^{-3}) = 388.35 \times 10^{-6}\ F/V.s = \boxed{388\ \mu A/V^2}$

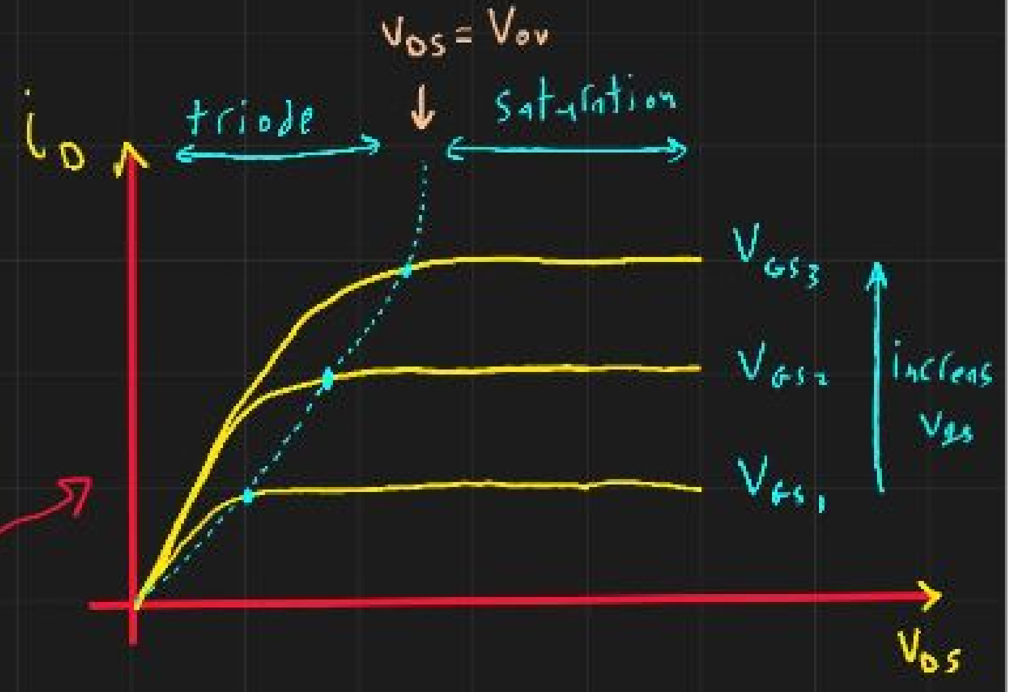
b) $\dfrac{W}{L} = \dfrac{1.8\ \mu m}{0.18\ \mu m}$ Calculate V_{ov}, V_{GS} and $V_{DS_{min}}$ in Saturation $i_D = 100\ \mu A$

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

$\therefore 100\ \mu A = \frac{1}{2} (388\ \mu A) \left(\frac{1.8}{0.18}\right) (V_{ov})^2 \longrightarrow \therefore \boxed{V_{ov} = 0.23\ v}$

$\rightarrow \therefore V_{ov} = V_{GS} - V_t \longrightarrow \therefore 0.23 = V_{GS} - 0.5 \longrightarrow \therefore \boxed{V_{GS} = 0.73\ v}$

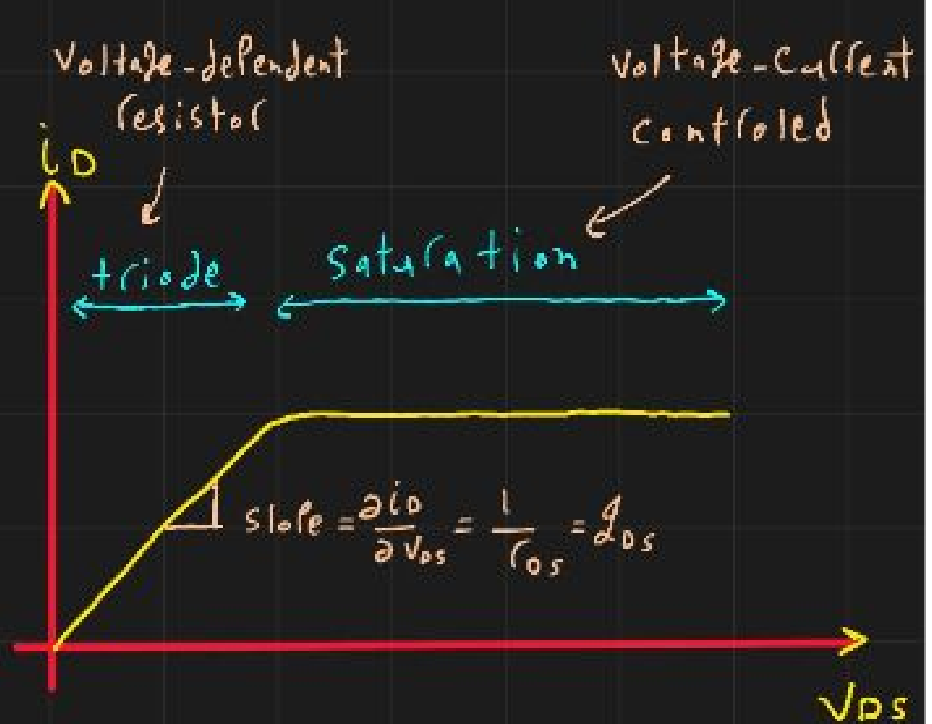
$\rightarrow \boxed{V_{DS_{min}} = V_{ov} = 0.23}$ Why?



c) for device in (b) find V_{ov}, V_{GS} to operate as a 1000 Ω resistor for small V_{DS}

in the triode region

small signal model



$\rightarrow$ in triode region $i_D = k_n \left(V_{ov} V_{DS} - \frac{1}{2} V_{DS}^2\right)$

$\therefore g_{DS} = \dfrac{\partial i_D}{\partial V_{DS}} \longrightarrow \therefore g_{DS} = k_n V_{ov} = k_n' \left(\frac{W}{L}\right) V_{ov}$

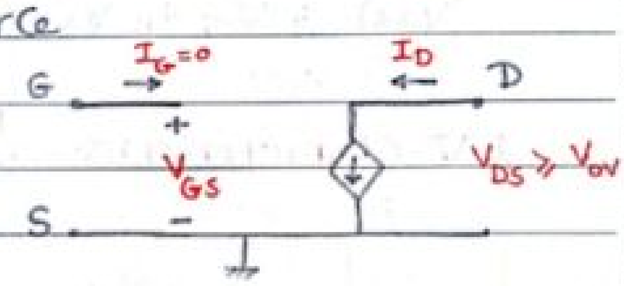
$\therefore g_{DS} = \dfrac{1}{r_{DS}} \longrightarrow \therefore g_{DS} = \dfrac{1}{1000}$

$\therefore \dfrac{1}{1000} = k_n' \left(\frac{W}{L}\right) V_{ov}$

$\therefore \dfrac{1}{1000} = 388 \times 10^{-6} \times 10\ (V_{ov}) \longrightarrow \therefore \boxed{V_{ov} = 0.26\ v}$

* ~~large~~ small Signal model in Saturation

Voltage Control Curren Source



I_G ← صغيرجداً بسبب طبقة ال oxide

I_D ← احنا في حالة Saturation

$$i_D = \frac{K_n}{2}(V_{GS} - V_t)^2$$

Ex (5.2) Page (265)

NMOS

$W = 2\ \mu m$ $\quad L = 0.18\ \mu m$ $\quad C_{ox} = 8.6\ fF/\mu m^2$

$\mu_n = 450\ cm^2/V.s$ $\quad V_{tn} = 0.5\ V$

a) find : $i_D = 100\ \mu A$ $\quad V_{GS}, V_{DS}$ $\quad$ saturation

$\because i_D = \frac{1}{2}K_n(V_{GS}-V_t)^2 = \frac{1}{2}(\mu C_{ox})(\frac{W}{L})(V_{GS}-V_{th})^2$

$\therefore 100 \times 10^{-6} = \frac{1}{2}(450 \times 10^{-4} \times 8.6 \times \frac{10^{-15}}{10^{-12}})(\frac{2 \times 10^{-6}}{0.18 \times 10^{-6}})(V_{GS} - 0.5)^2$

$\therefore V_{GS} = 0.72\ v$

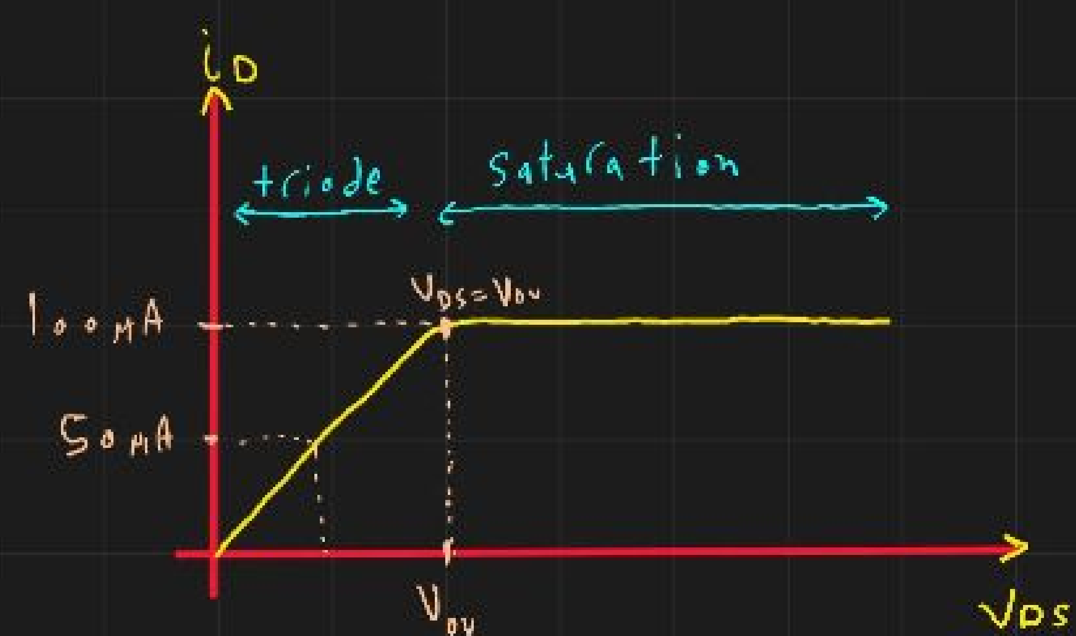
$\therefore V_{DS} = V_{ov} = 0.72 - 0.5$

$\therefore V_{DS} = 0.22\ v$

b) V_{GS} Kept Const find V_{DS} at $i_D = 50\ \mu A$

$\because V_{GS}$ is Kept Constant $\rightsquigarrow \therefore V_{ov}$ is the same too.

→ $50\ \mu A$ is more likly to be in the triode region.



$\therefore i_D = K_n(V_{ov}V_{DS} - \frac{1}{2}V_{DS}^2)$

$\therefore 50 \times 10^{-6} = 4.3 \times 10^{-3}[0.22\,V_{DS} - \frac{1}{2}V_{DS}^2]$

$\therefore V_{DS} = 0.06\ v$	$\therefore V_{DS} = 0.39\ v$
$V_{DS} < V_{ov}$ ✓	$V_{DS} > V_{ov}$ ✗
accepted	rejected $\rightsquigarrow$ in triode $V_{DS} < V_{ov}$

$\therefore$ opperates in the triode region.