

21-8-12

Lec 11

$V_{A,max,1}$ (triode)

$$\left. \begin{aligned} V_D &= V_{DS,1} - g_m(R_L) \cdot V_A \\ V_A &= V_{AS,1} + V_A \end{aligned} \right\} \begin{array}{l} \text{apply} \\ V_D = V_A - V_T \end{array}$$

$$\Rightarrow 3.75 - 5 \cdot V_A = 1.5 + V_A - 1$$

$$V_{A,max,1} = \frac{3.25}{6} = 541.67 \text{ mV}$$

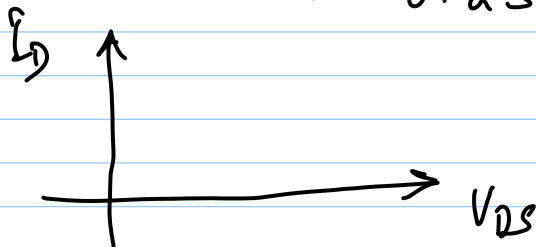
Cutoff $V_{A,max,2}$

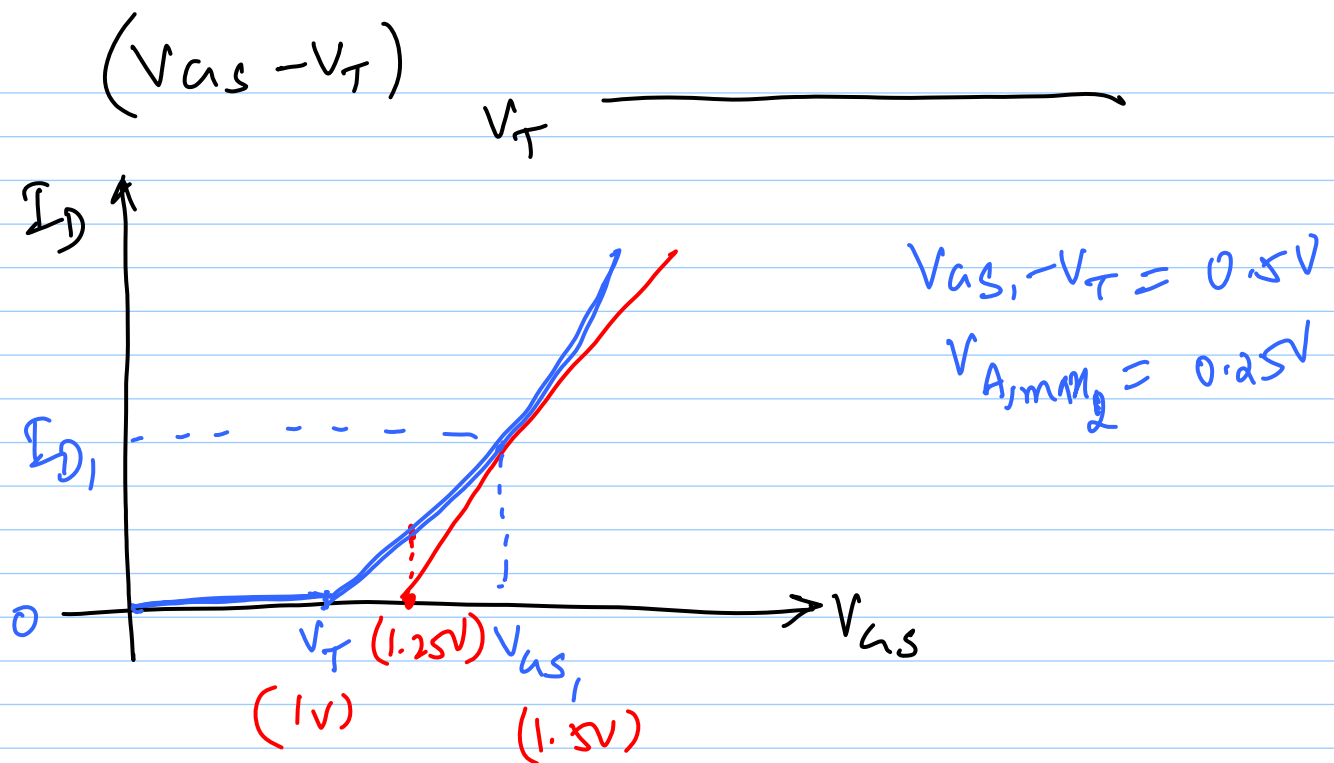
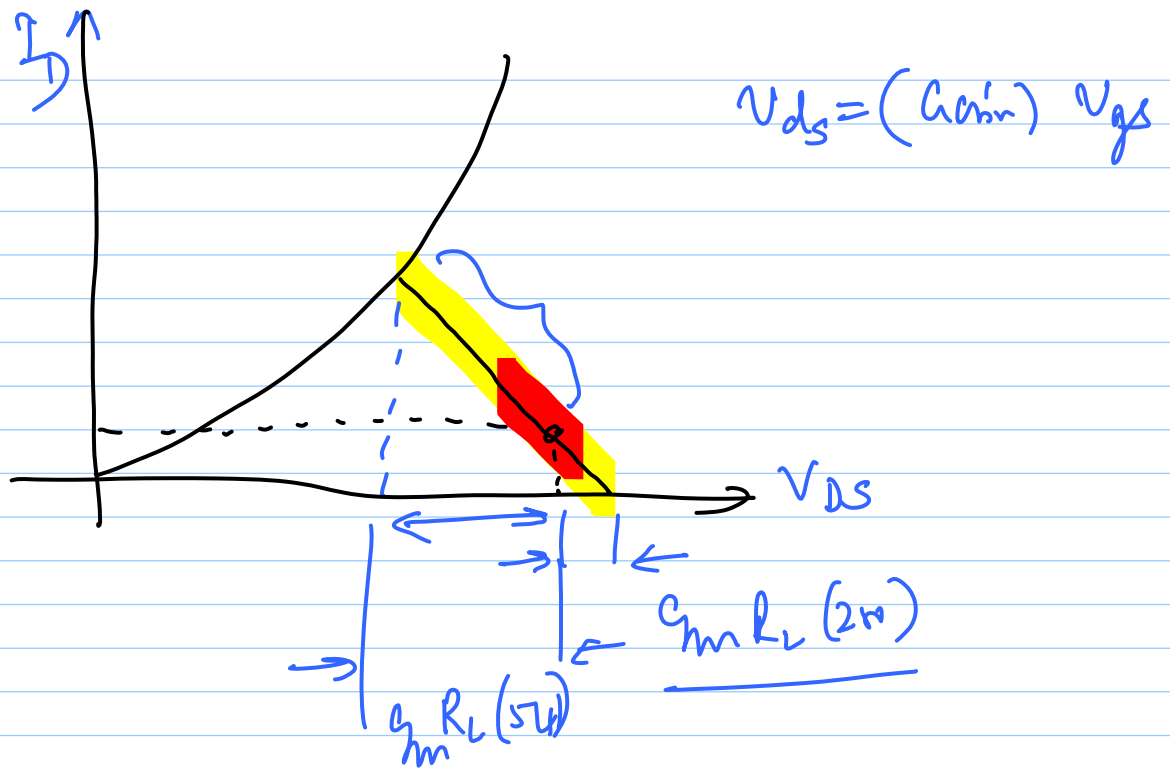
$$I_{D,1} = g_m V_A$$

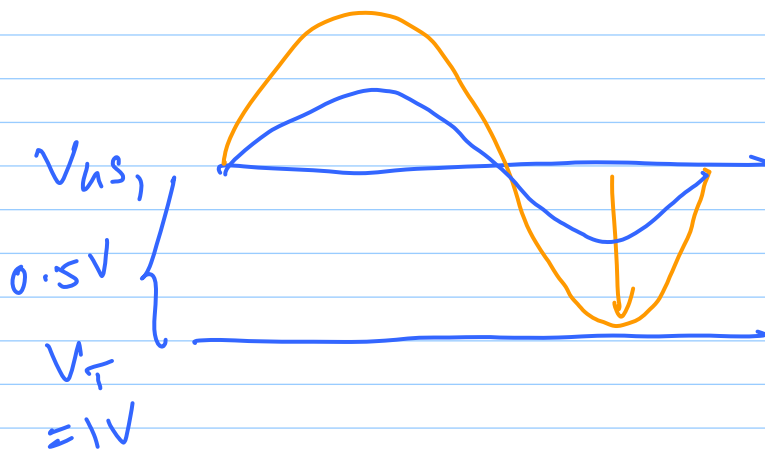
$$125 \mu\text{A} = 0.5 \text{ mS} \cdot V_A$$

$$V_{A,max,2} = 0.25 \text{ V}$$

$$\begin{aligned} V_{A,max} &= \min(V_{A,max,1}, V_{A,max,2}) \\ &= 0.25 \text{ V} \end{aligned}$$







I_D sat.

$$I_D = \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L} \right) (V_{as} - V_T)^2$$

$$I_D = f(V_{as}, V_{ds})$$

$$I_D + i_d = f(V_{as} + v_{gs}, V_{ds} + v_{ds})$$

$$= \underbrace{f(V_{as}, V_{ds})}_{\text{DC}} + \frac{\partial I_D}{\partial V_{as}} \cdot v_{gs} + \frac{\partial I_D}{\partial V_{ds}} \cdot v_{ds} \\ + \frac{1}{2} \frac{\partial^2 I_D}{\partial V_{as}^2} \cdot v_{gs}^2 + \frac{1}{2} \frac{\partial^2 I_D}{\partial V_{ds}^2} \cdot v_{ds}^2$$

$$+ \frac{\partial^2 I_D}{\partial V_{DS} \partial V_{GS}} \cdot v_{gs} \cdot v_{ds} + \dots$$

$$= I_D + g_m v_{gs} + \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L} \right) \cdot v_{gs}^2$$

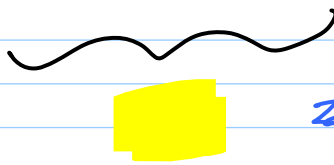
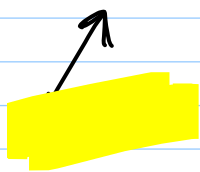
$$i_d = \underbrace{g_m v_{gs}}_{\text{I}} + \underbrace{\frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L} \right) \cdot v_{gs}^2}_{\text{II}}$$

$$\text{II} \ll \text{I}$$

$$g_m v_{gs} \gg \frac{1}{2} \mu_n C_{ox} \left(\frac{W}{L} \right) \cdot v_{gs}^2$$

$$\cancel{\mu_n C_{ox} \left(\frac{W}{L} \right)} (V_{GS} - V_T) \cdot v_{gs} \gg \frac{1}{2} \cancel{\mu_n C_{ox} \left(\frac{W}{L} \right)} \cdot v_{gs}^2$$

$$v_{gs} \ll 2 (V_{GS} - V_T) \iff$$



$\iff$ not too small
(25%)

