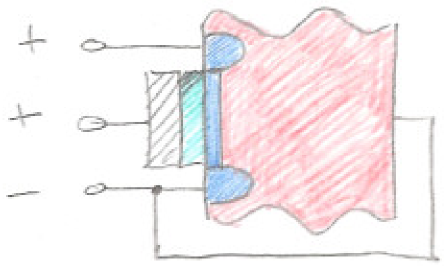
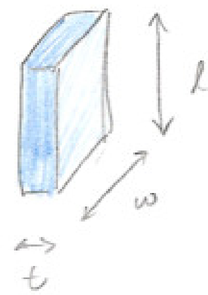
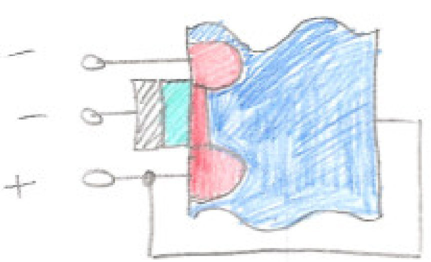
N-CHANNEL MOSFET





$$R_{ch} = \rho_n \cdot \frac{l}{l \cdot w}$$

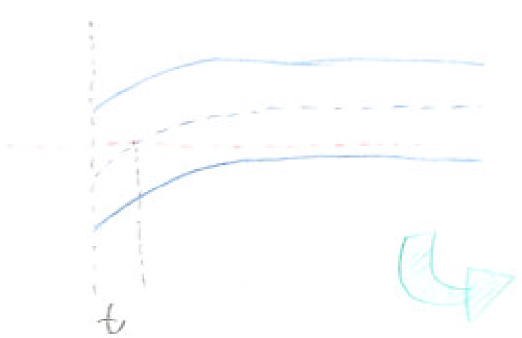
P-CHANNEL MOSFET



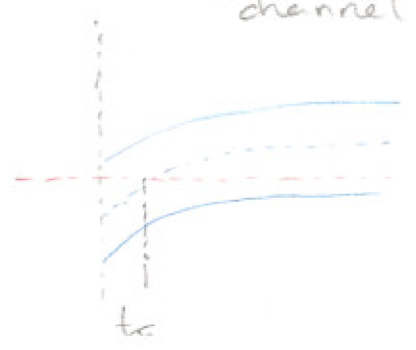
note: notice that the voltage polarity is reversed.

note: both of these examples are the case when V_{GS} is small.

when V_{DS} is not small

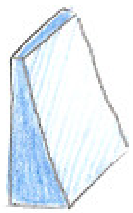


note: t_s is the middle of the channel

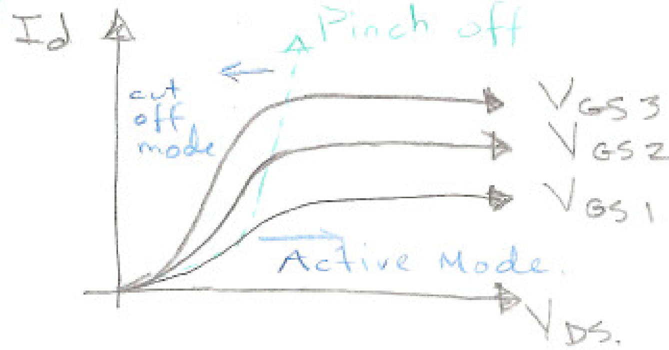


$t = t_s$

However the thickness at different points will be different, and the channel will take on the form:



note: this is known as the Pinch off effect of the channel.



$V_{GS3} > V_{GS2} > V_{GS1}$

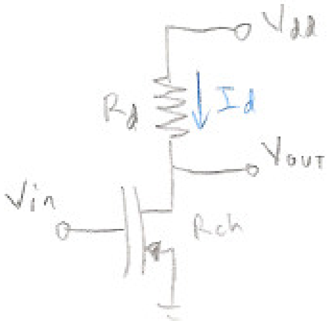
$I_d = 0$ when $V_{GS} < V_T$

$$R_{ch} = \frac{\rho w}{t} \cdot \frac{l}{w} = R_{no} \cdot \frac{l}{w}$$

($\frac{\rho w}{t}$: R_{no}; $\frac{l}{w}$: constant)

$$\boxed{R_{no} = f(I_d)}$$

P-channel works in very much the same way.



$V_{in} < V_T \rightarrow I_d = 0$

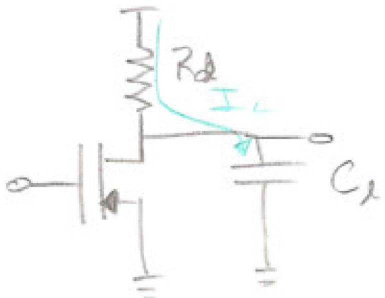
$V_{out} \approx V_{dd}$

$V_{in} > V_T \rightarrow I_d \neq 0$

$V_{out} < V_{dd}$

$$V_{out}^{0} = I_d R_{ch}$$

because there is no current flowing through gates, we have an equivalent capacitance.



when $V_{GS} < V_T$ then another "charging current" is produced.

"I_c"

$$V_{dd} = R_d C \frac{d v_c(t)}{dt} + V_c(t)$$

$\Delta t_{0 \to 1}$

$$V_c(\Delta t_{0 \to 1}) = V_{out}' = V_{dd}\left(1 - e^{-\frac{\Delta t_{0 \to 1}}{\tau}}\right)$$

$$\frac{V_{out}'}{V_{dd}} = 1 - e^{-\frac{\Delta t_{0 \to 1}}{\tau}}$$

$$e^{-\frac{\Delta t_{0 \to 1}}{\tau}} = 1 - \frac{V_{out}'}{V_{dd}}$$

$$-\Delta t_{0 \to 1} = \tau \ln\left(1 - \frac{V_{out}'}{V_{dd}}\right)$$

$$\Delta t_{0 \to 1} = -RC \ln\left(1 - \frac{V_{out}'}{V_{dd}}\right)$$