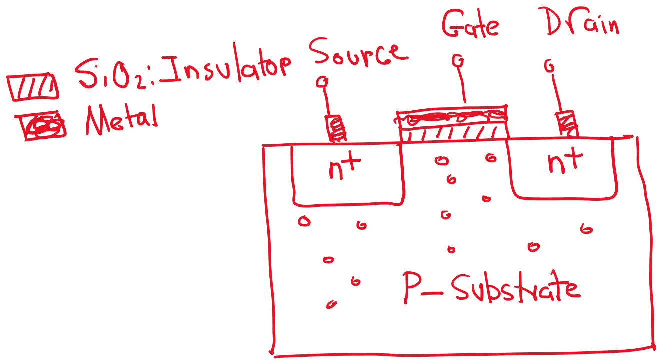
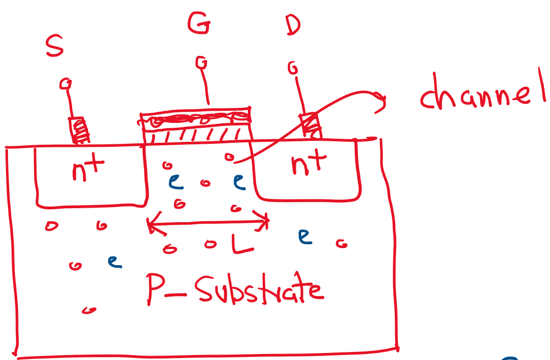
MOSFET_Lecture_1

Friday, July 18, 2025 5:09 PM

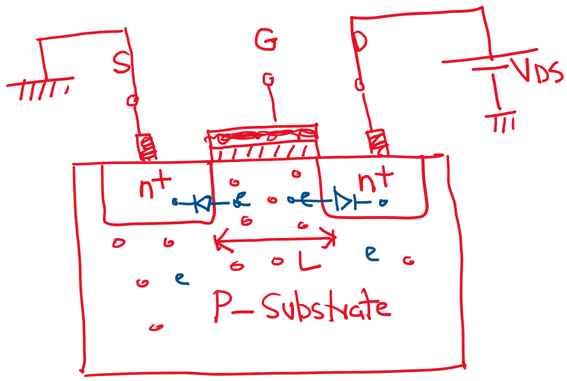
MOSFET: Metal Oxide Semiconductor Field Effect Transistor



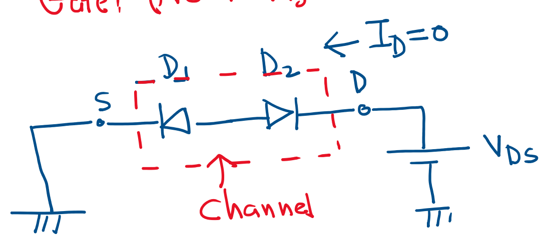
1B → 1 hole
P: Hole Maj
e: Electron Min.
n^+: Heavily doped (Huge amount of P are added)

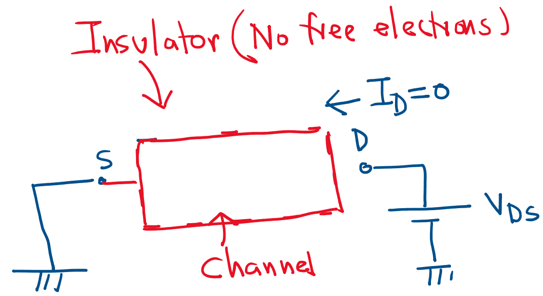


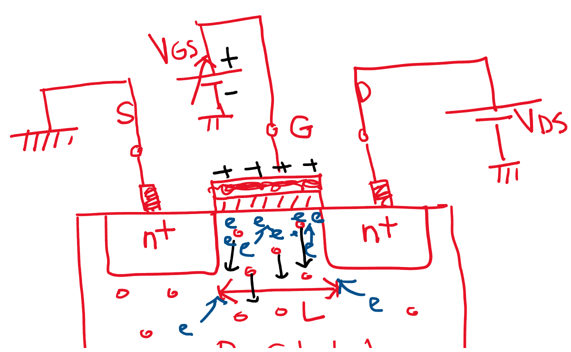
Case I.



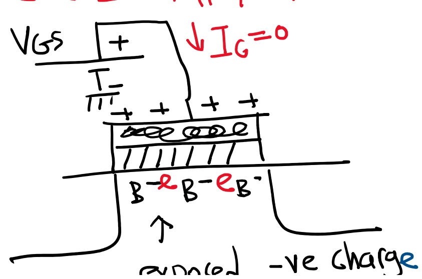
Gate: (No voltage)

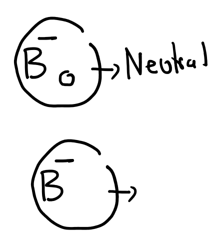


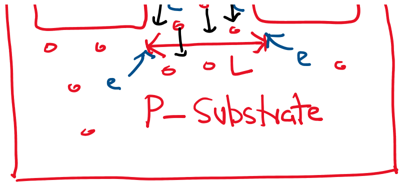


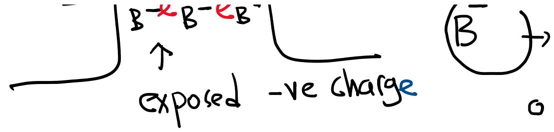


Case II: Apply V_{GS}: (+ve)

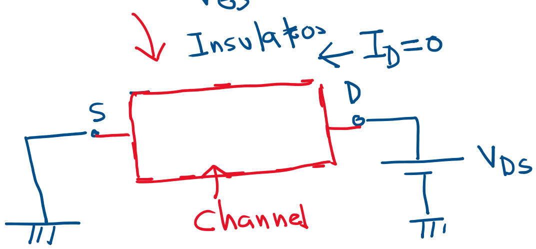






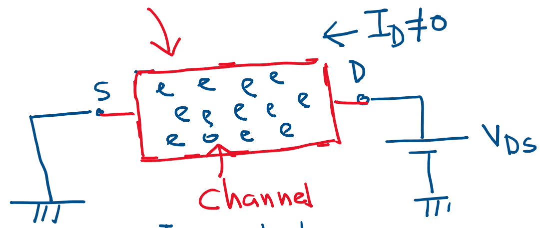


$V_{GS}=0$



Insulator (ch)

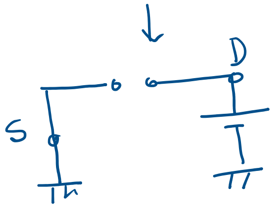
$V_{GS}>0$

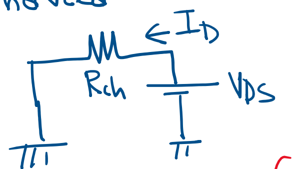


Is conductive

Conductor (ch)

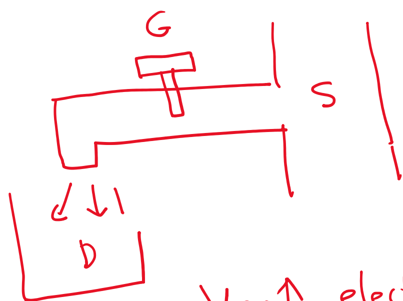
A conducting channel has been Induced





$I_D = \dfrac{V_{DS}}{R_{ch}}$

Cut-off Transistor: Transfer Resistor (ON)

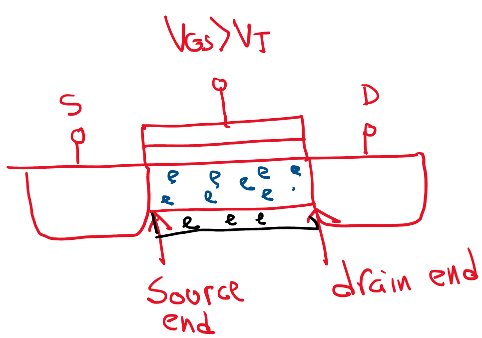


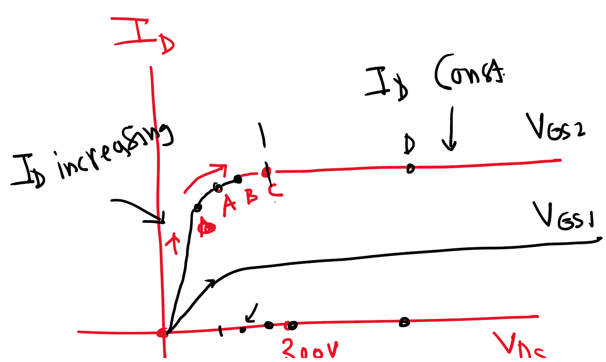
$V_{GS}\uparrow$, electron Accumulation at Oxide / Semiconductor Interface (ch region) $\uparrow$

V_T (threshold Voltage).

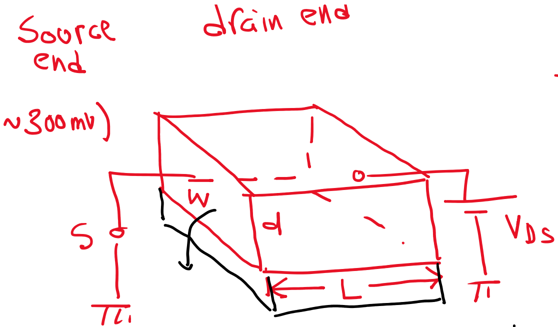
Value of V_{GS} at which Sufficient # of electrons accumulate under the oxide layer to create a conducting Channel is known as V_T.

$V_{GS}>V_T$

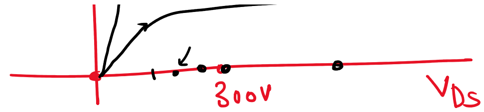




Small V_{DS} (0~300mV)

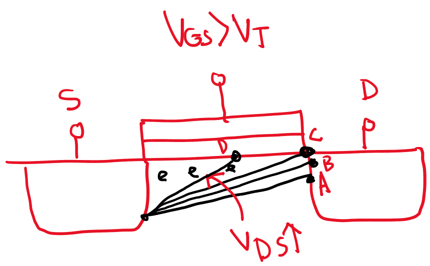


$R_{ch} \propto \frac{1}{A}$



$I_{D_1} = \frac{V_{DS_1}}{R_{ch_1}}$, $I_D \propto V_{DS}$

$I_{D_2} = \frac{V_{DS}}{R_{ch_2}}$, $R_{ch_2} < R_{ch_1}$

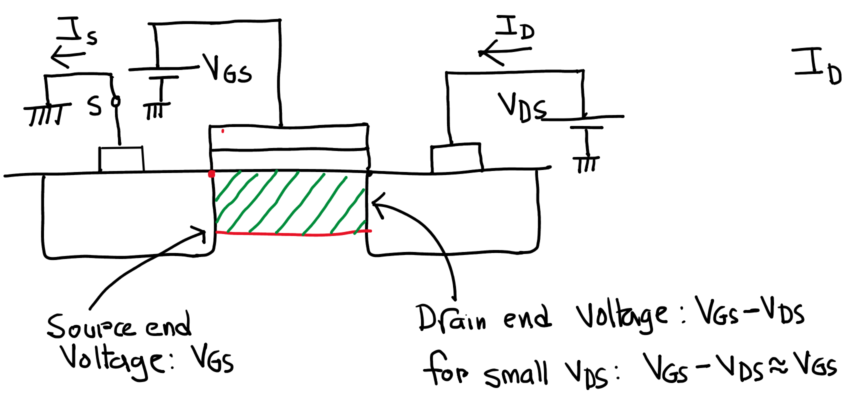


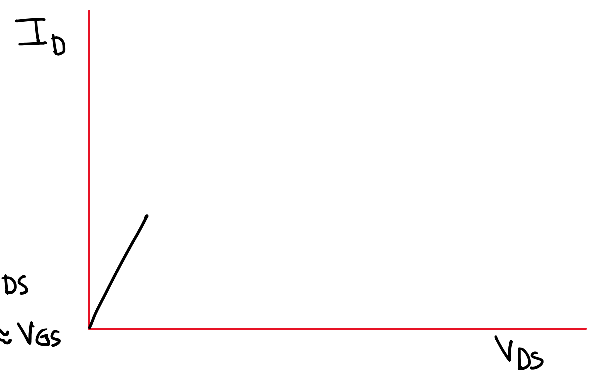
Position: C : pinch off : Maximum drain current

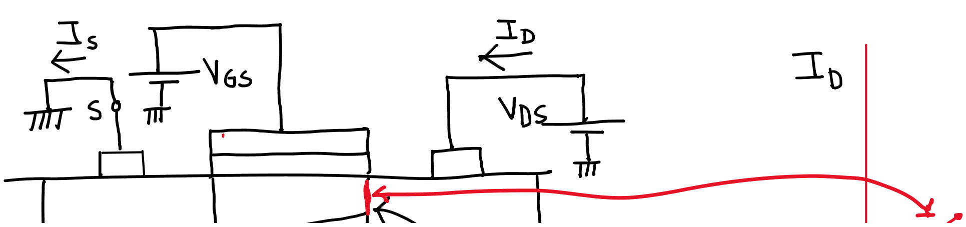
Position D : ch. doesn't exist at the drain end.

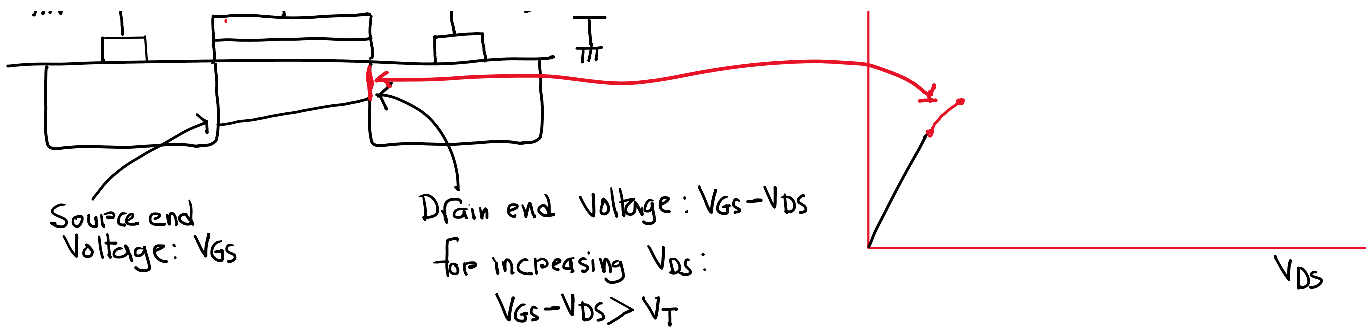
I_D increasing → Having channel at the drain end (A, B, C)

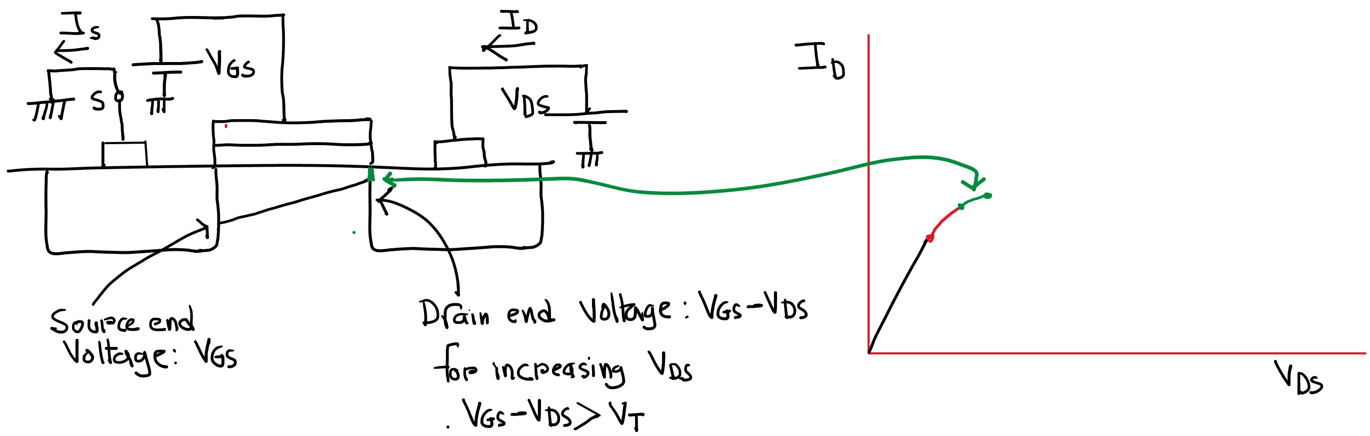
I_D Constant → channel doesn't exists at the drain end. (D)

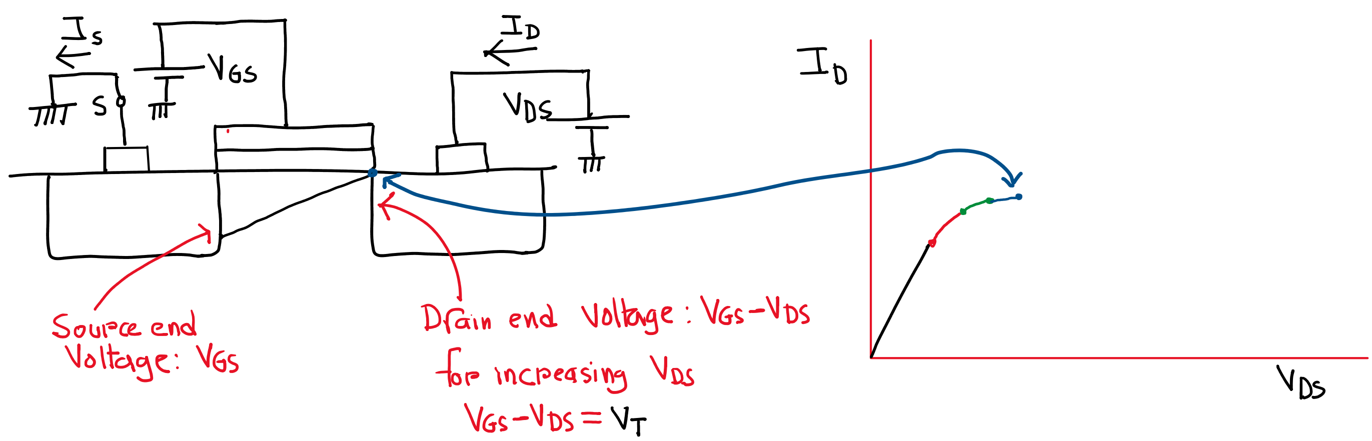


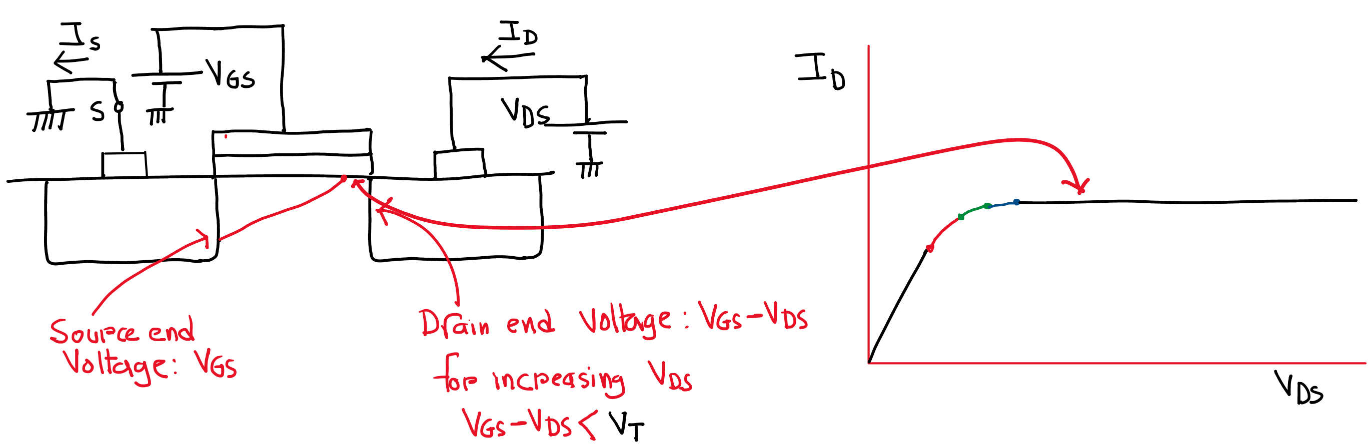


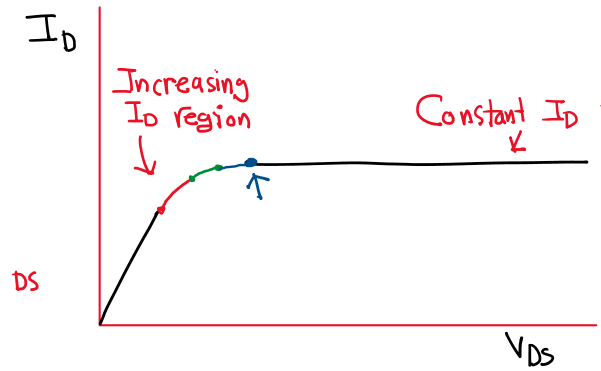



Source end
Voltage: VGS
Drain end Voltage: VGS-VDS
for increasing VDS:
VGS-VDS > VT
VDS


IS
S
VGS
ID
VDS
Source end
Voltage: VGS
Drain end Voltage: VGS-VDS
for increasing VDS
VGS-VDS > VT
VDS

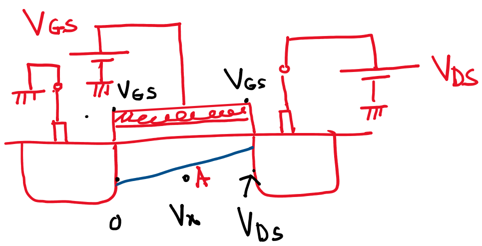

IS
S
VGS
ID
VDS
Source end
Voltage: VGS
Drain end Voltage: VGS-VDS
for increasing VDS
VGS-VDS = VT
VDS


IS
S
VGS
ID
VDS
Source end
Voltage: VGS
Drain end Voltage: VGS-VDS
for increasing VDS
VGS-VDS < VT
VDS



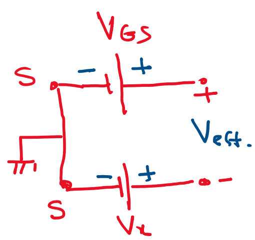
Increasing I_D region $\longrightarrow$ $V_{GS} - V_{DS} > V_T \rightarrow$ channel exists at drain end

Constant I_D region $\longrightarrow$ $V_{GS} - V_{DS} < V_T \rightarrow$ No channel exists at drain end



$\longleftarrow$ Voltage V_{DS} drops along the channel., V_{DS} at drain end and 0 at source end.

lets consider, at position A the voltage along the channel is V_x, So the effective voltage betn gate and position A. can be shown in the following way:



Applying KVL around the loop:

$+V_{GS} - V_{eff} - V_x = 0$

$\Rightarrow \boxed{V_{eff} = V_{GS} - V_x}$

at the source end: $V_x = 0$ [ground.] $\rightarrow$ $V_{eff} = V_{GS} - 0 = V_{GS}$

at the drain end: $V_x = V_{DS}$ $\rightarrow$ $V_{eff} = V_{GS} - V_{DS}$

Since chennel depth $\propto V_{eff}$ [effective voltage betn gate and ch.]

at source end: $V_{eff} = V_{GS} \uparrow$, ch. depth maximum (d_1)

at drain end $V_{eff} = (V_{GS} - V_{DS}) \downarrow$. ch. depth min. (d_2)

at source end: $V_{GS} = V_{GS} \uparrow$. ch. depth maximum (d_1)

at drain end $V_{eH} = (V_{GS} - V_{DS}) \downarrow$. ch. depth min. (d_2)