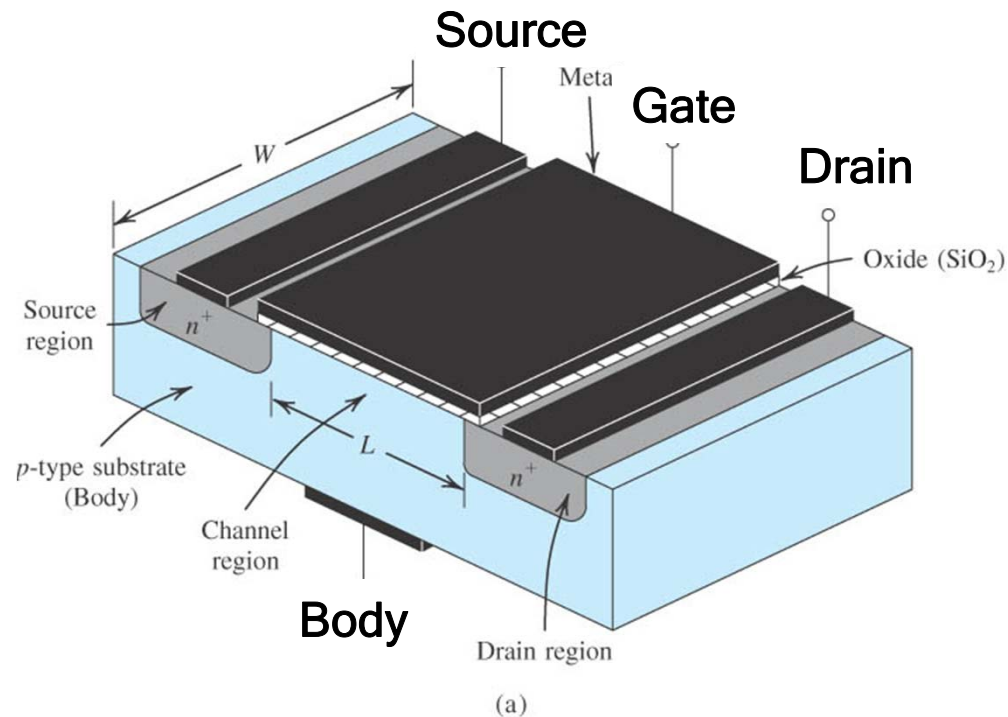


Lect. 19: MOSFET

(Razavi 6.2,6.3)

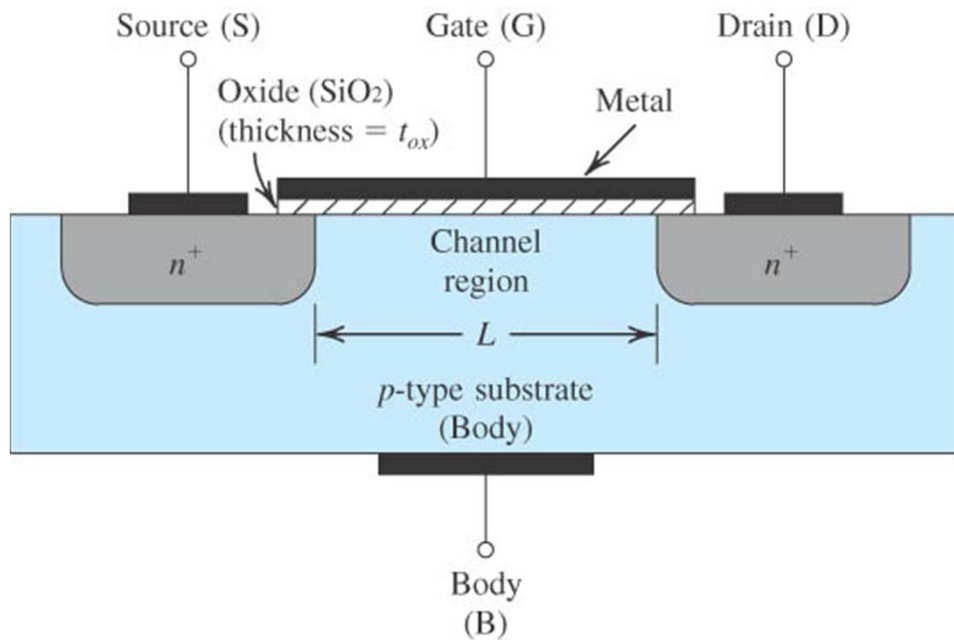
MOSFET: Metal Oxide Semiconductor Field Effect Transistor



Control current flow between S and D with voltage applied at G
NMOS, PMOS

Lect. 19: MOSFET

NMOS: n-channel MOSFET

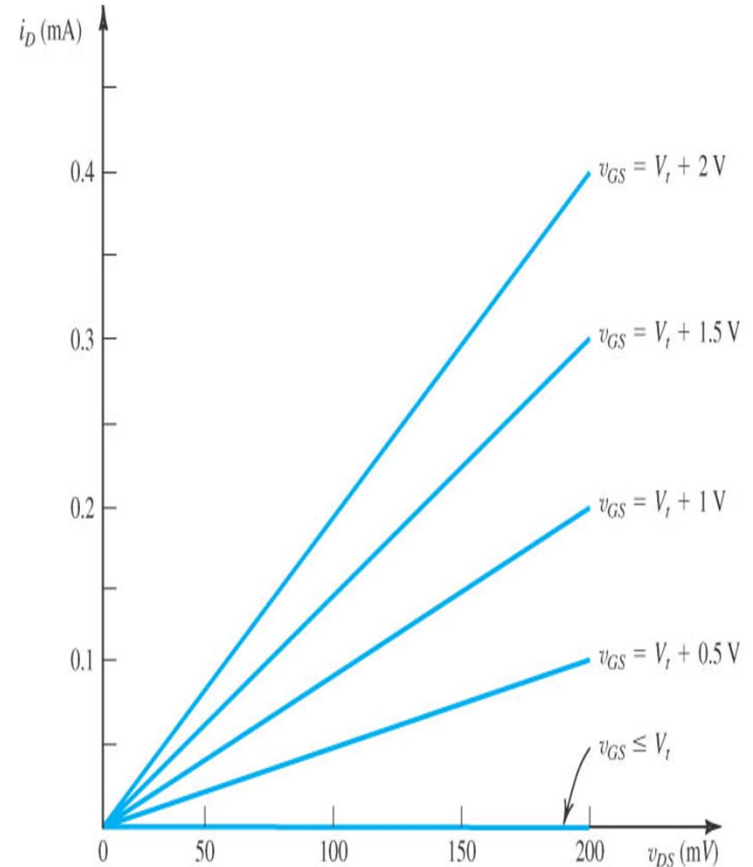
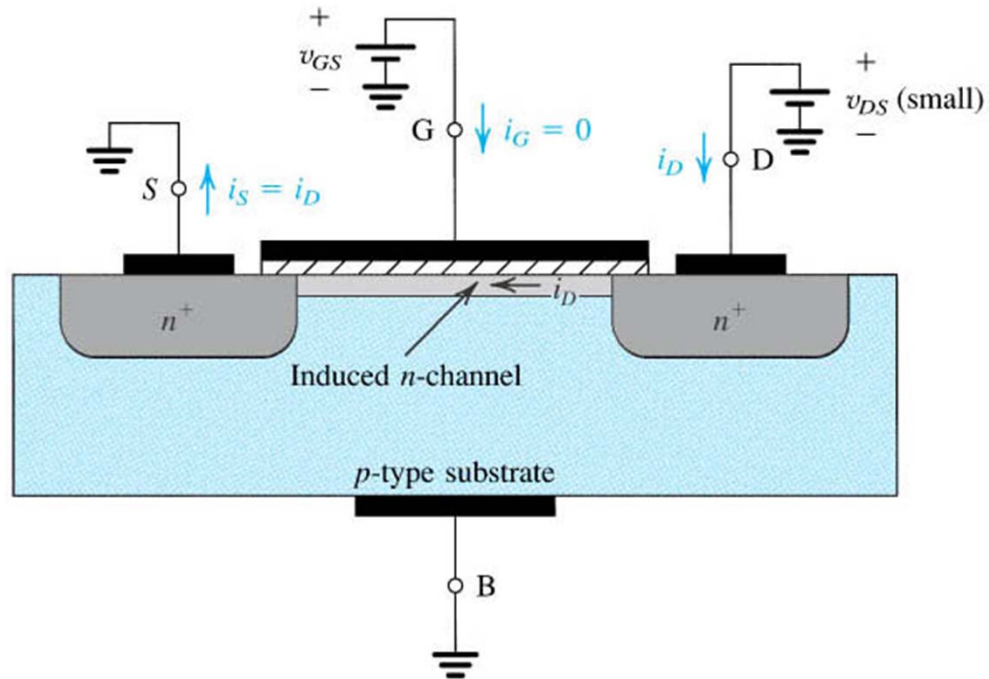


Can currents flow between S and D?

→ Need carriers (electrons)

→ Apply gate voltage ($v_{GS} > V_T > 0$)
(V_T : Threshold voltage)

Lect. 19: MOSFET



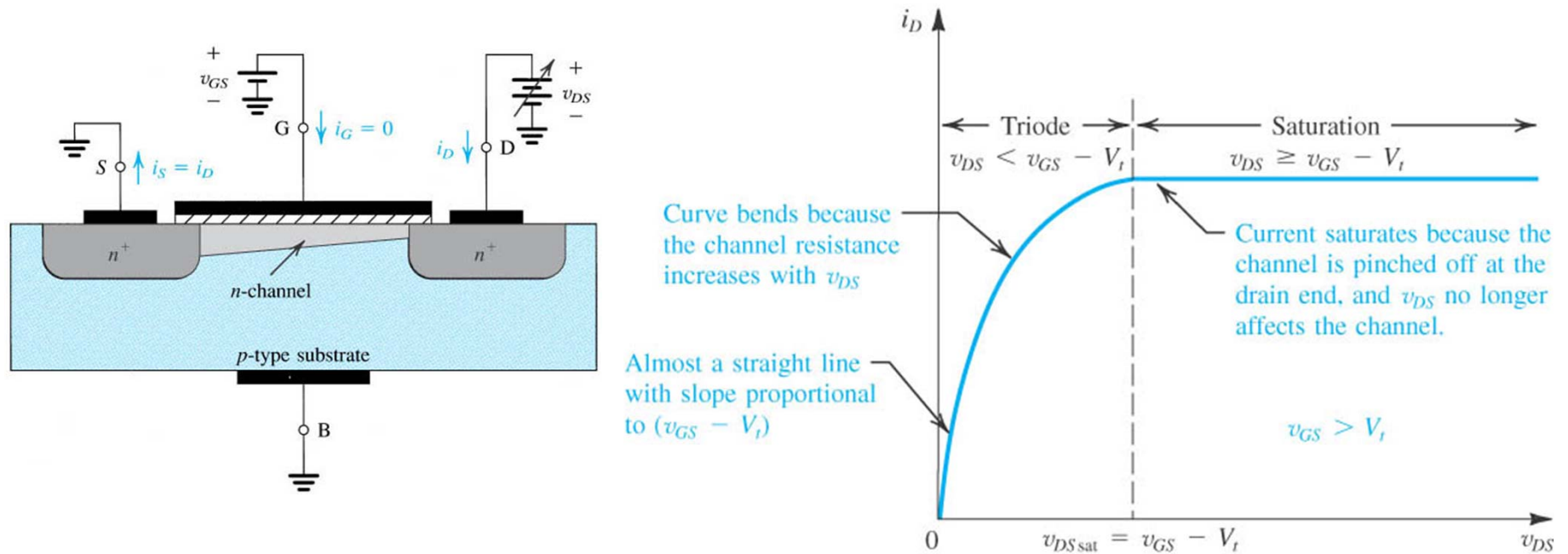
With $v_{GS} > v_T$ (threshold voltage), channel is formed.

(Gate and p-substrate is acting as a capacitor)

More carriers with higher v_{GS}

How does i_D change with v_{DS} ?

Lect. 19: MOSFET



- With v_{DS} increase, i_D begins to saturate

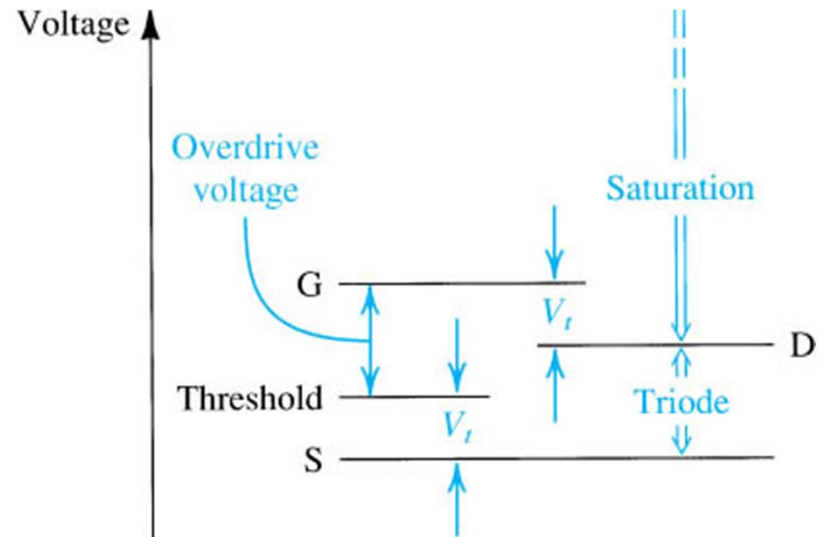
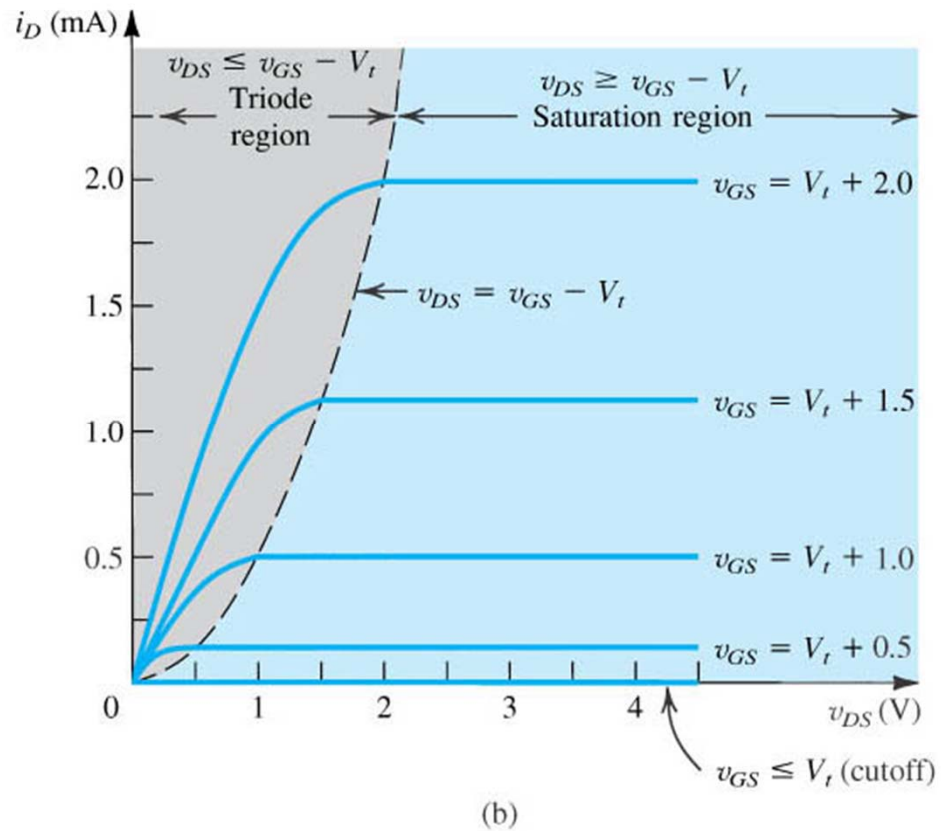
→ Less carriers in Drain side ($v_{GD} = v_{GS} + v_{SD} = v_{GS} - v_{DS}$)

When $v_{DS} = v_{GS} - v_T$, ($v_{GD} = v_T$), channel is pinched off

→ No further increase in i_D

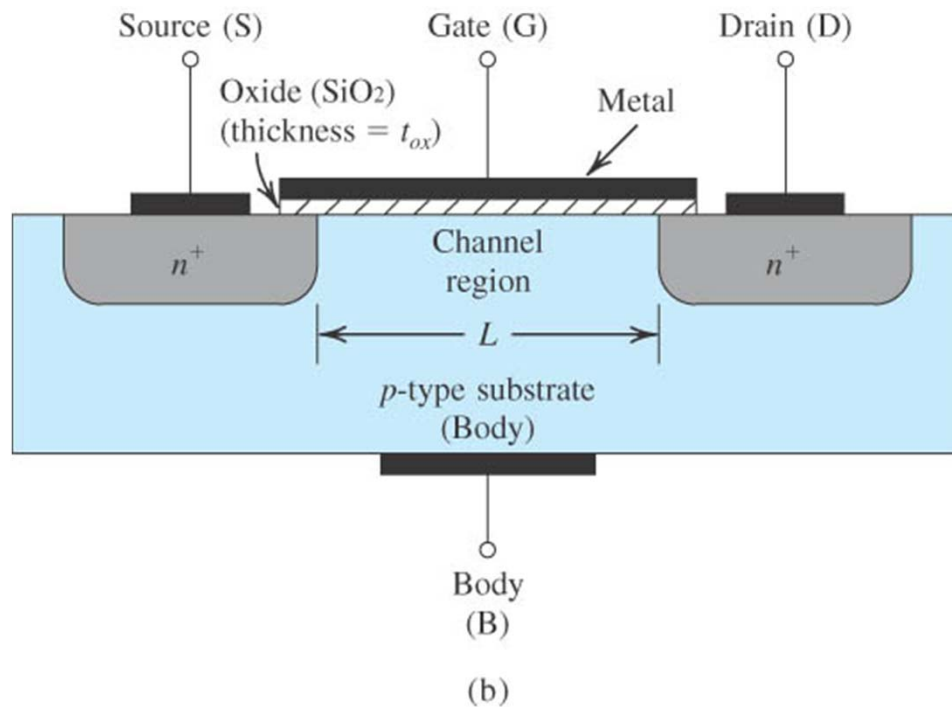
Lect. 19: MOSFET

MOSFET (NMOS) I-V Characteristics

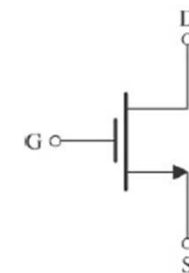
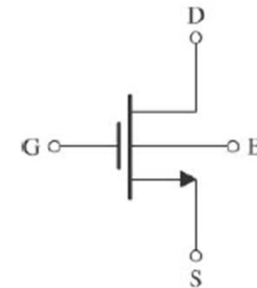
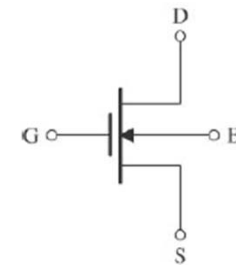


Lect. 19: MOSFET

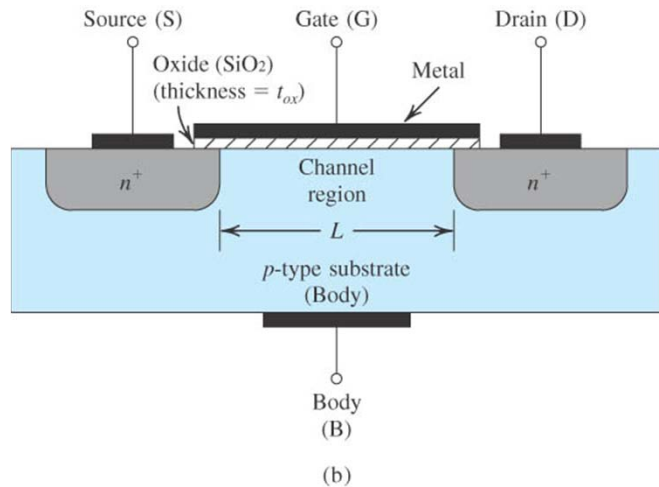
NMOS: n-channel MOSFET



Circuit Symbols



Lect. 19: MOSFET



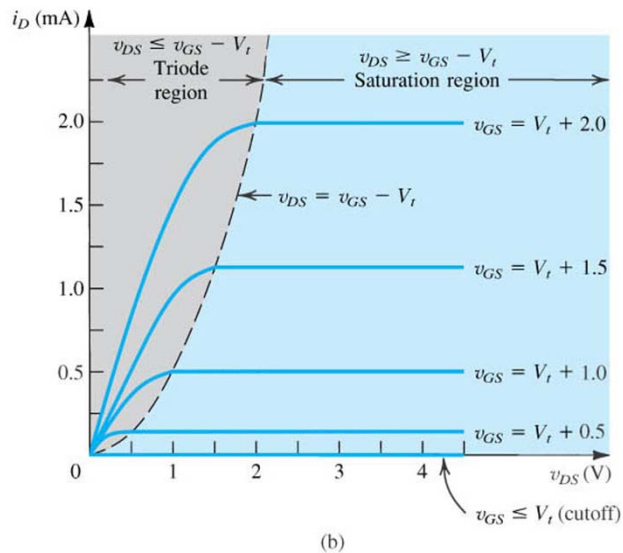
With more in-depth analyses,

$$\text{In triode, } i_D = \mu_n C_{ox} \frac{W}{L} \left[(v_{GS} - V_t) \cdot v_{DS} - \frac{1}{2} v_{DS}^2 \right]$$

$$(v_{GS} > V_t \text{ and } v_{DS} \leq v_{GS} - V_t)$$

$$\text{In saturation, } i_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (v_{GS} - V_t)^2$$

$$(v_{GS} > V_t \text{ and } v_{DS} \geq v_{GS} - V_t)$$



μ_n : electron mobility

C_{ox} : oxide capacitance

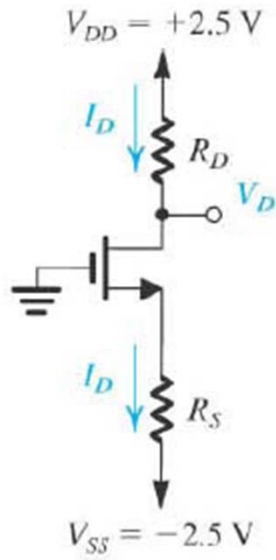
V_t : threshold voltage

$$k' = \mu_n C_{ox}$$

Lect. 19: MOSFET

Determine R_D and R_S so that $I_D = 0.4 \text{ mA}$ and $V_D = 0.5 \text{ V}$.

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

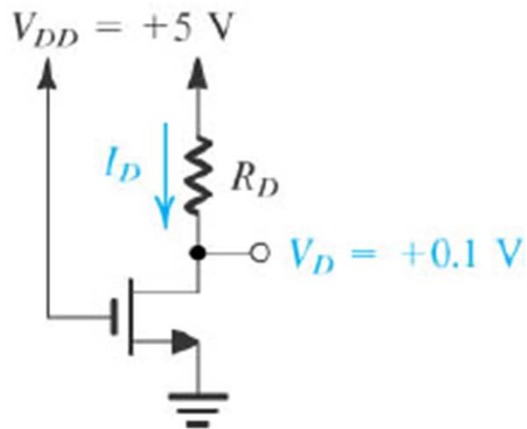


1. What region is the MOSFET in?
2. What is V_S ?
3. R_D and R_S ?

Lect. 19: MOSFET

Determine R_D so that $V_D = 0.1\text{V}$.

$$V_t = 1\text{V}, \mu_n C_{ox} W/L = 1\text{mA/V}^2$$



1. What region is the MOSFET in?
2. What is I_D ?
3. What is R_D ?

Lect. 19: MOSFET

Homework: (Due Nov. 11)

Example 6.6, 6.7, 6.8 in Razavi