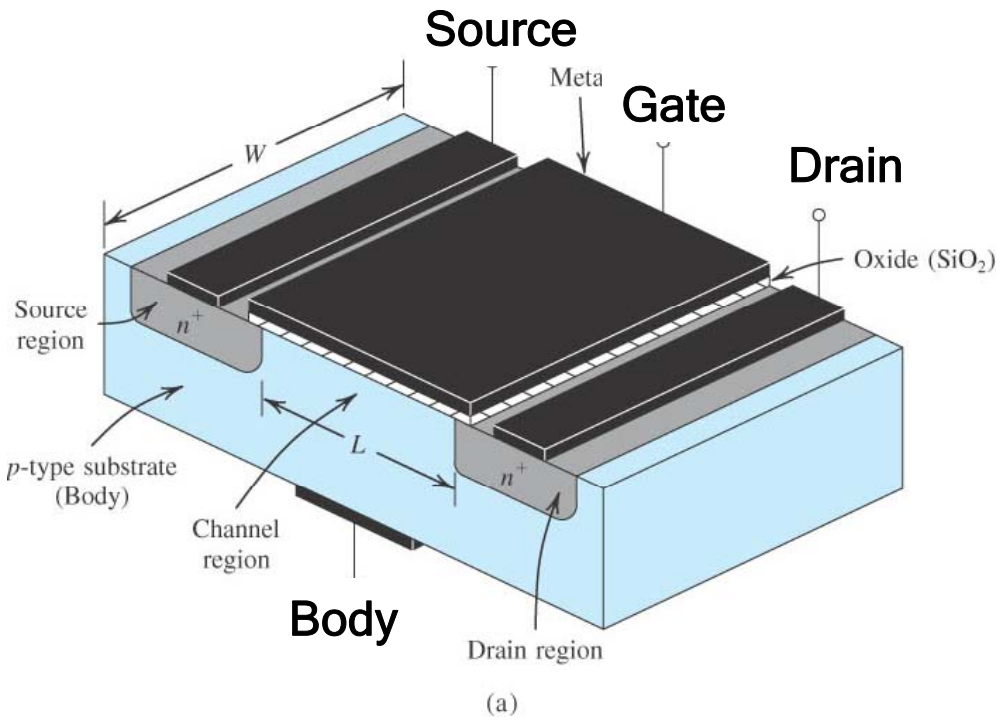
Lect. 19: MOSFET (Razavi 6.2,6.3)

MOSFET: Metal Oxide Semiconductor Field Effect Transistor



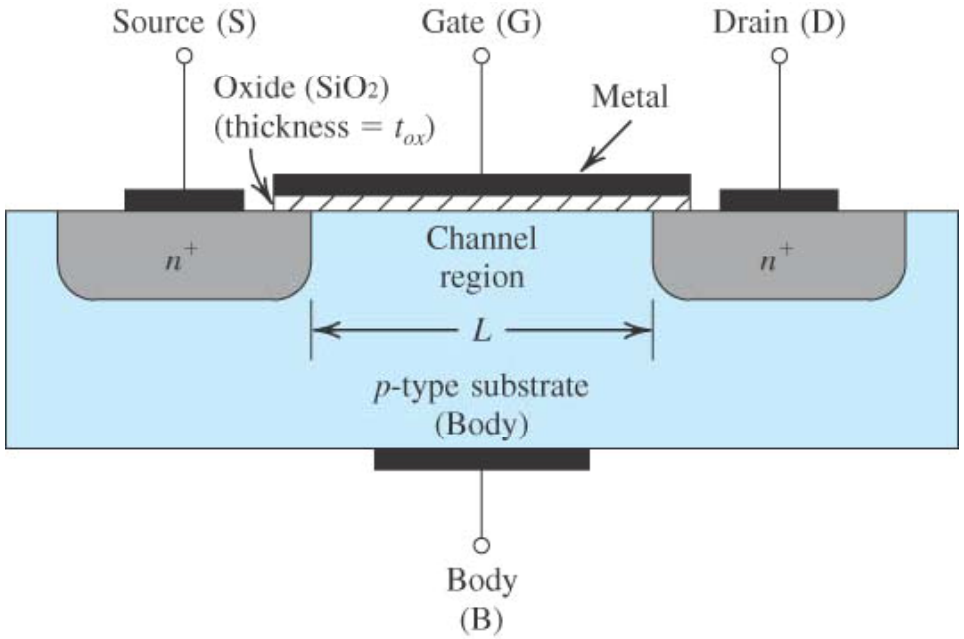
(a)

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)

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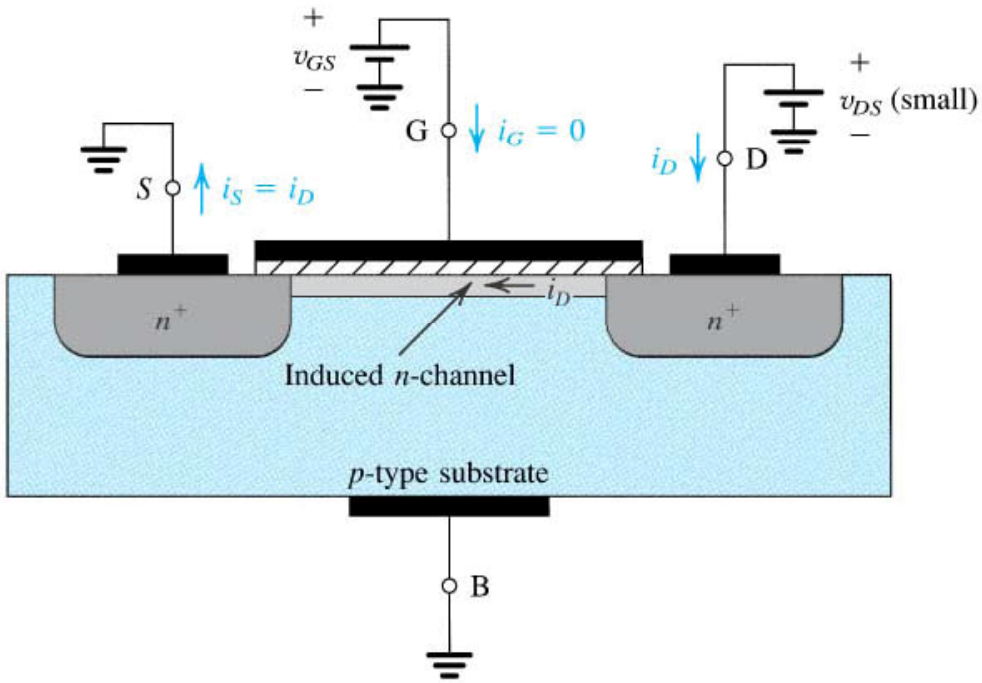
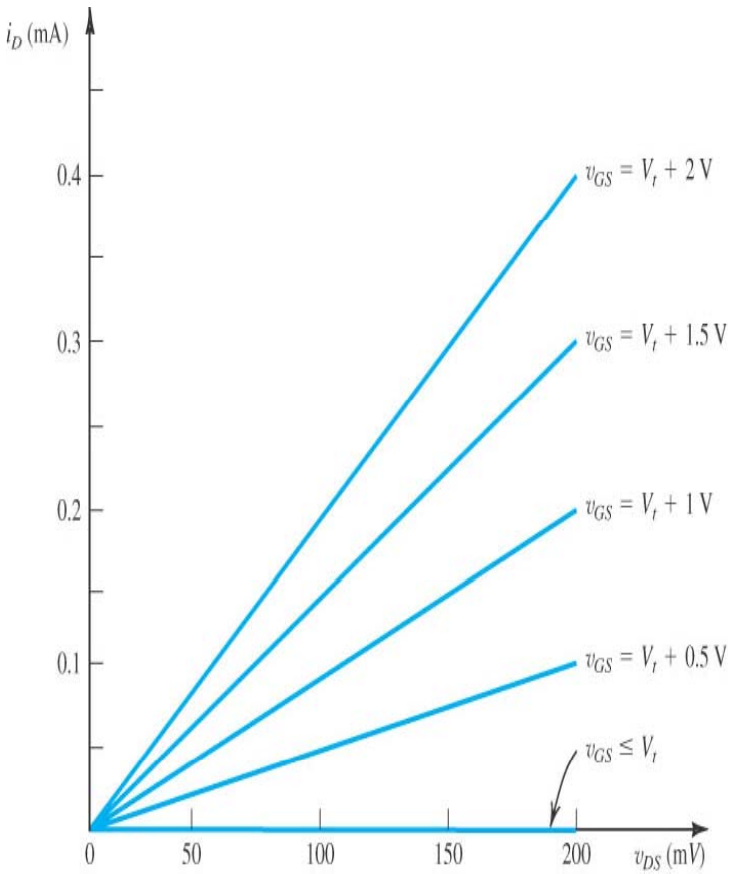




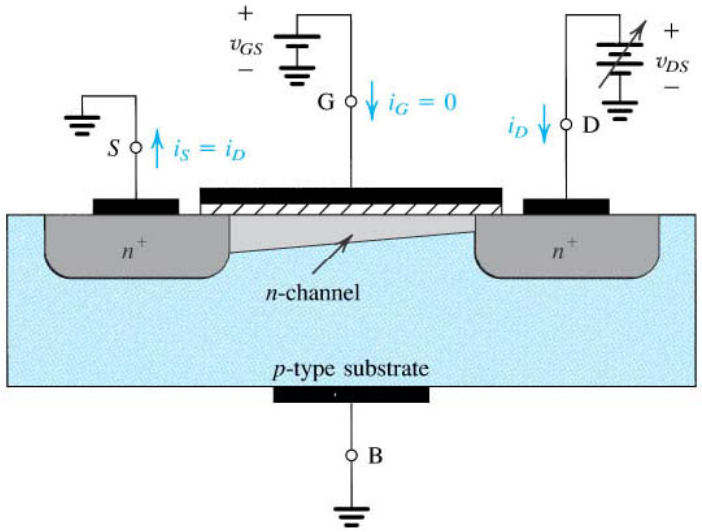
With $v_{GS}>v_T$ (threshold voltage), channel is formed.

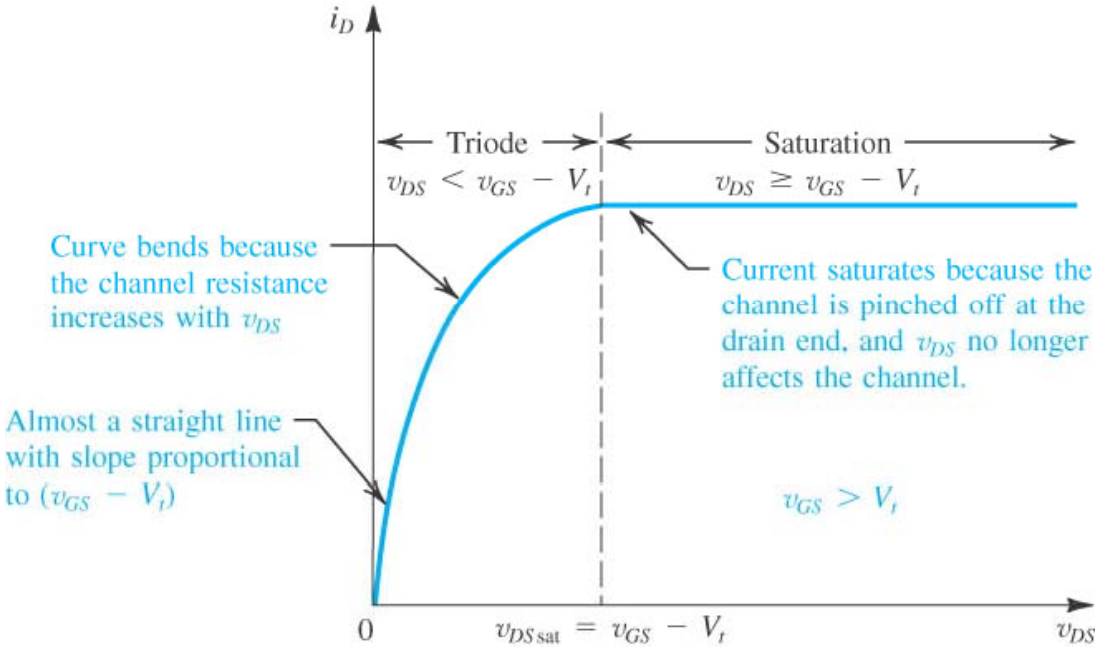
(Gate and p-substrate is acting as a capacitor)

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

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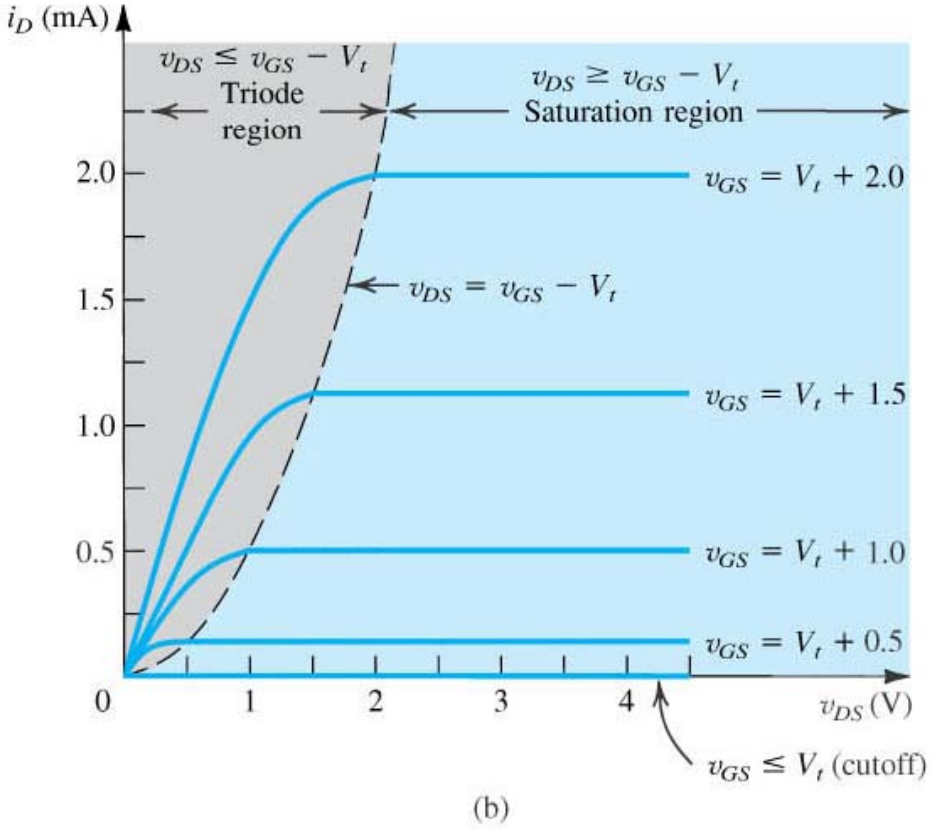
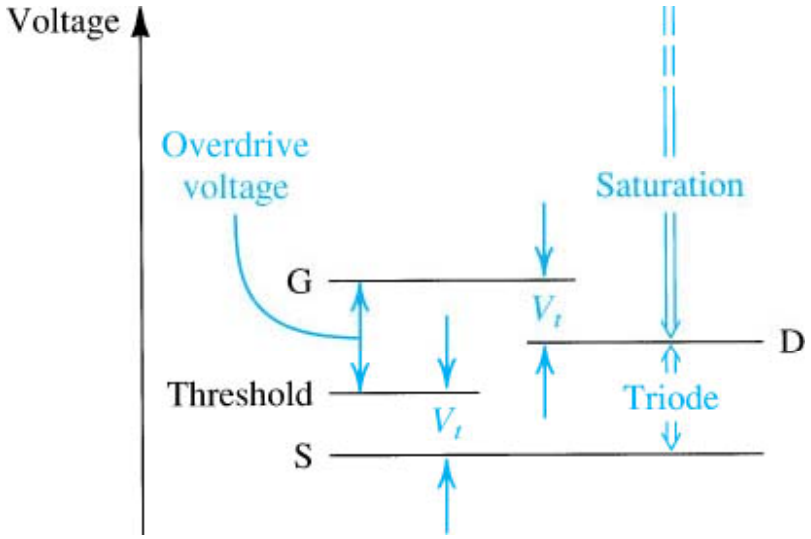
MOSFET (NMOS) I-V Characteristics

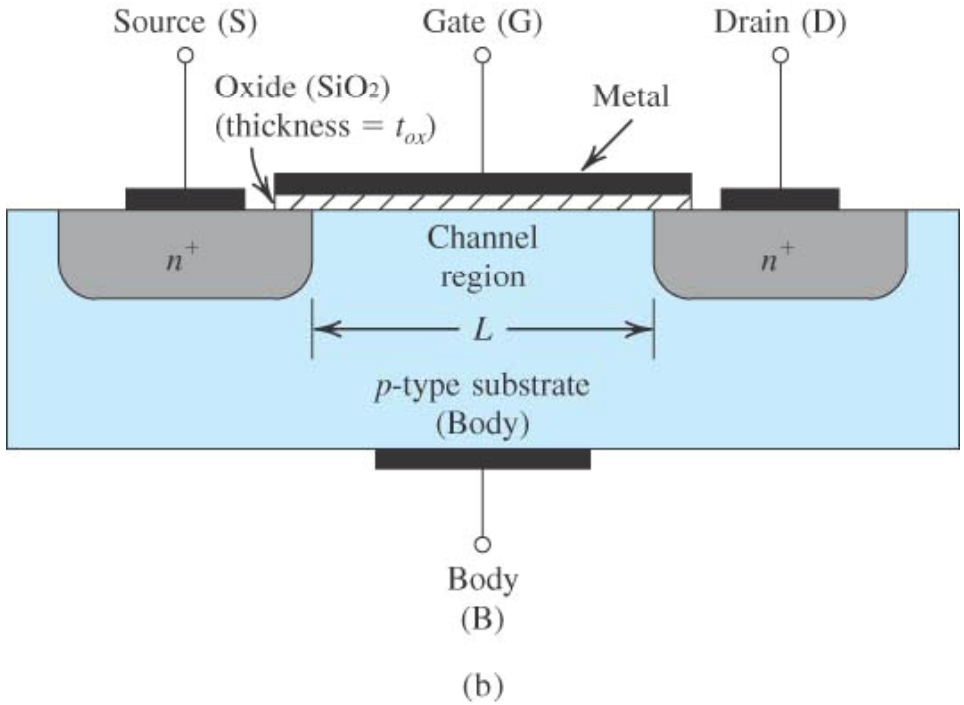


(b)



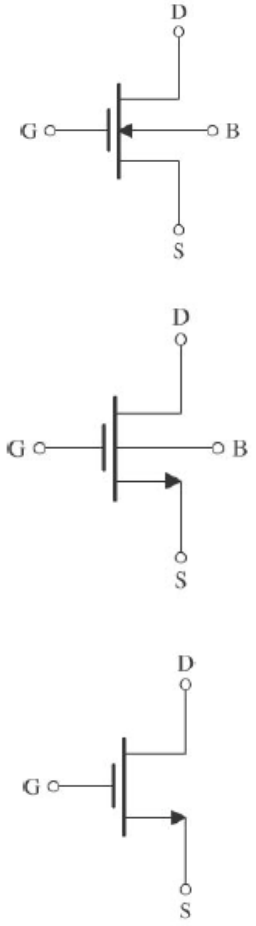
Lect. 19: MOSFET

NMOS: n-channel MOSFET

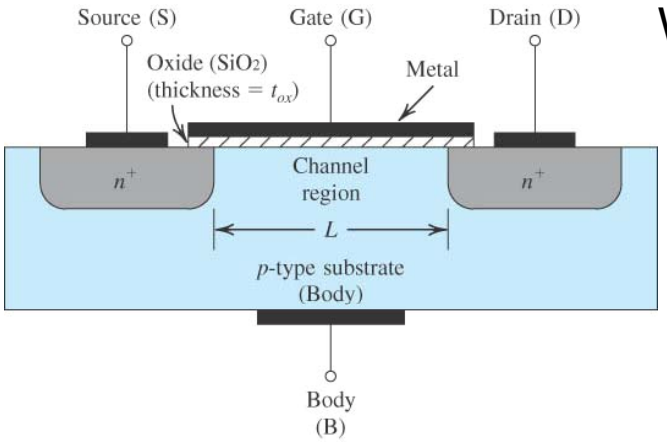


(b)

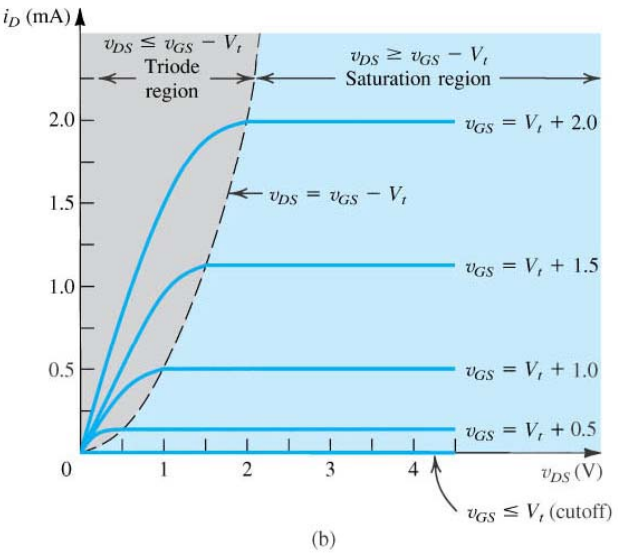
Circuit Symbols



Lect. 19: MOSFET



(b)



(b)

With more detailed analyses (but still approximate),

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

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

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

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

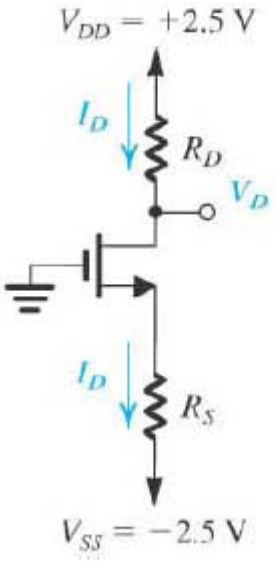
μ_n : electron mobility

C_{ox} : oxide capacitance

V_t : threshold voltage

$k' = \mu_n C_{ox}$

Lect. 19: MOSFET



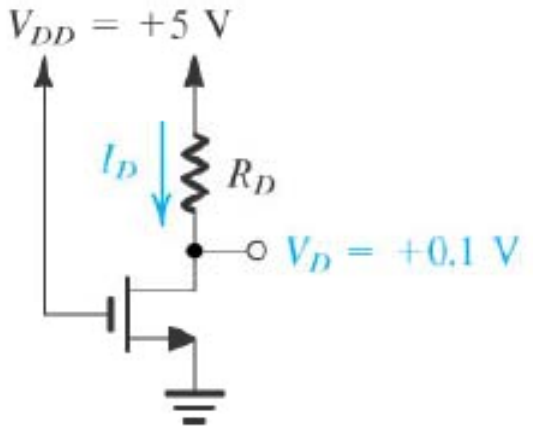
Determine R_D and R_S so that I_D=0.4 mA and V_D=0.5V.

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

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

Lect. 19: MOSFET

Example 4.4



Determine R_D so that V_D= 0.1V.

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

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