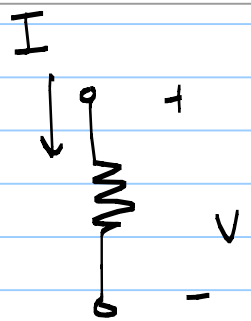
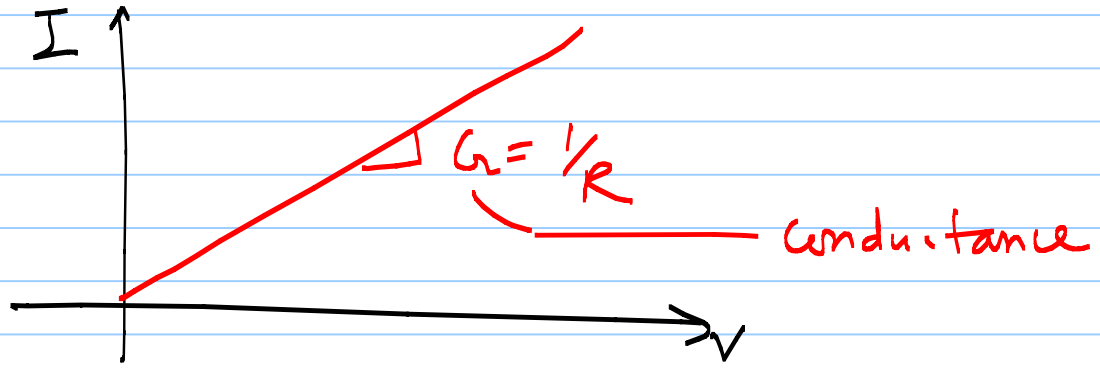
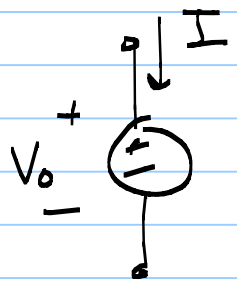
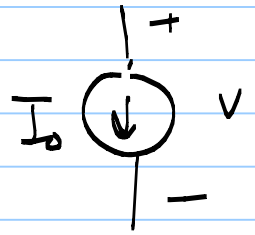
ECE511: Lecture 1.

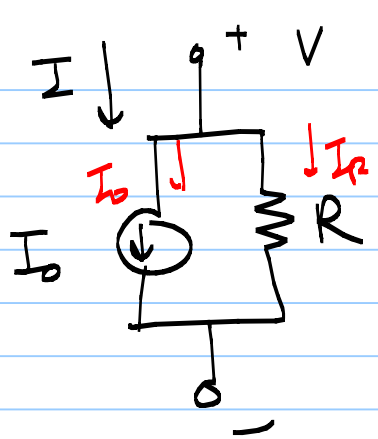
Note Title 1/19/2011

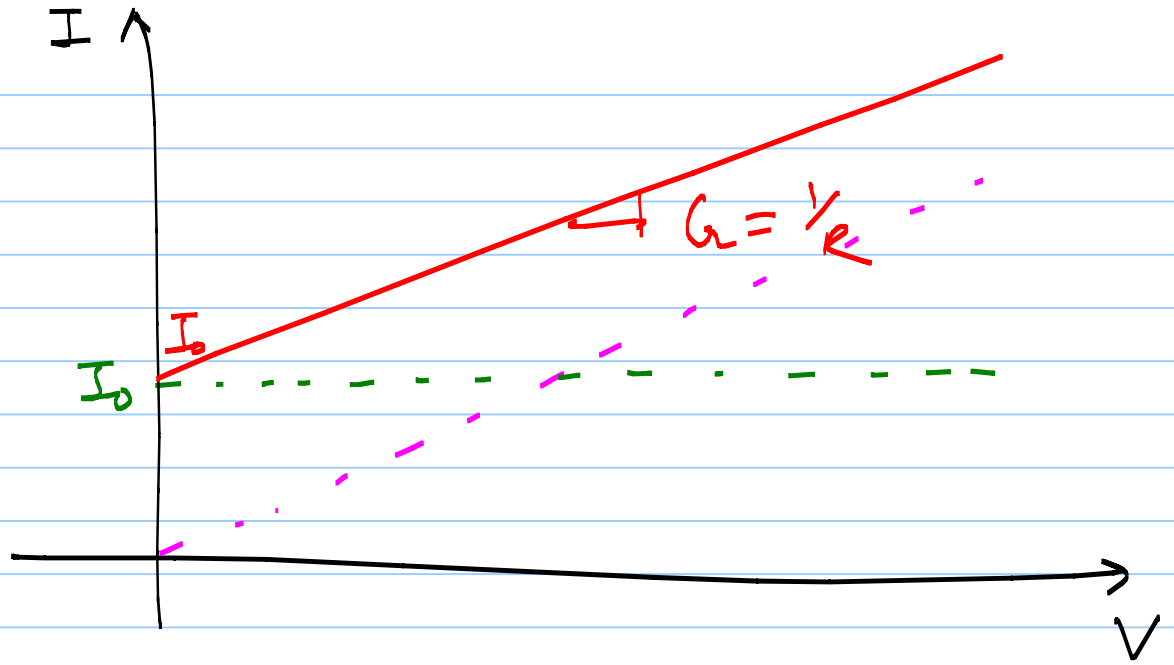




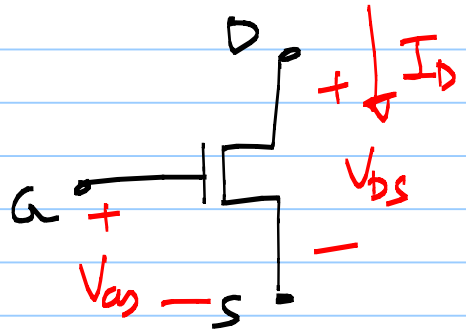





I
+
V
I_0
J
I_R
I_0
R
−


I
I_0
I_0
$G = 1/R$
V

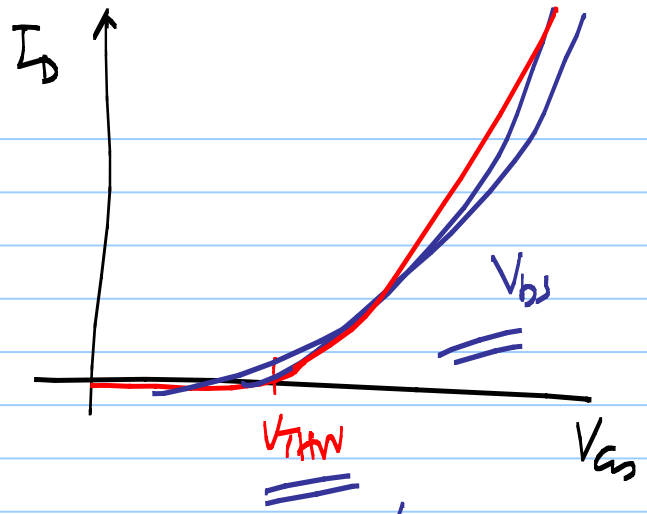
MOSFET I-V characteristics



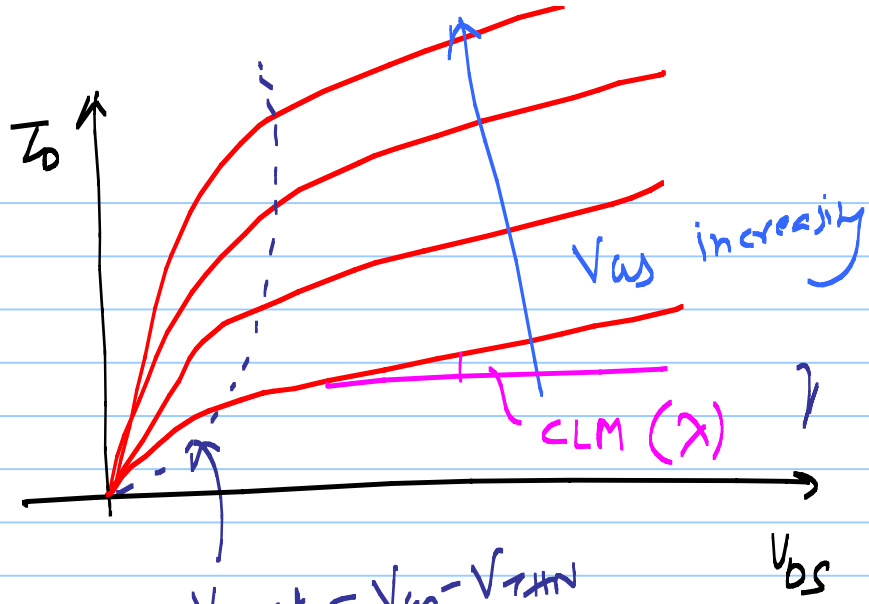
V_{GS}, V_{DS} → independent variable

I_D ← dependant

$$I_D = f(V_{GS}, V_{DS})$$

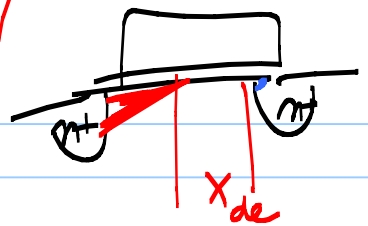


$V_{DS} = \text{const}$



$V_{DS,sat} = V_{GS} - V_{THN}$

① Saturation: $V_{DS} \geq V_{DS,sat} = V_{GS} - V_{THN}$



① Cutoff: $V_{GS} < V_{THN}$

② Triode: $V_{DS} < V_{DS,sat}$

$$I_D = K_n \frac{W}{L}\left[(V_{GS} - V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

③ Saturation: $V_{DS} > V_{DS,sat}$

$$I_D = \frac{K_n}{2}\frac{W}{L}(V_{GS} - V_{THN})^2\left[1 + \lambda(V_{DS} - V_{DS,sat})\right]$$

(Long channel)

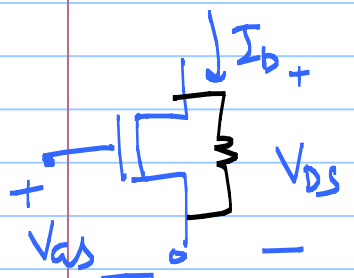
* $V_{DS,sat} = V_{GS} - V_{THN}$

  * gate 'overdrive' voltage
  * excess gate voltage

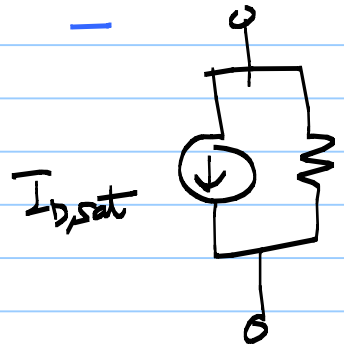
Saturation

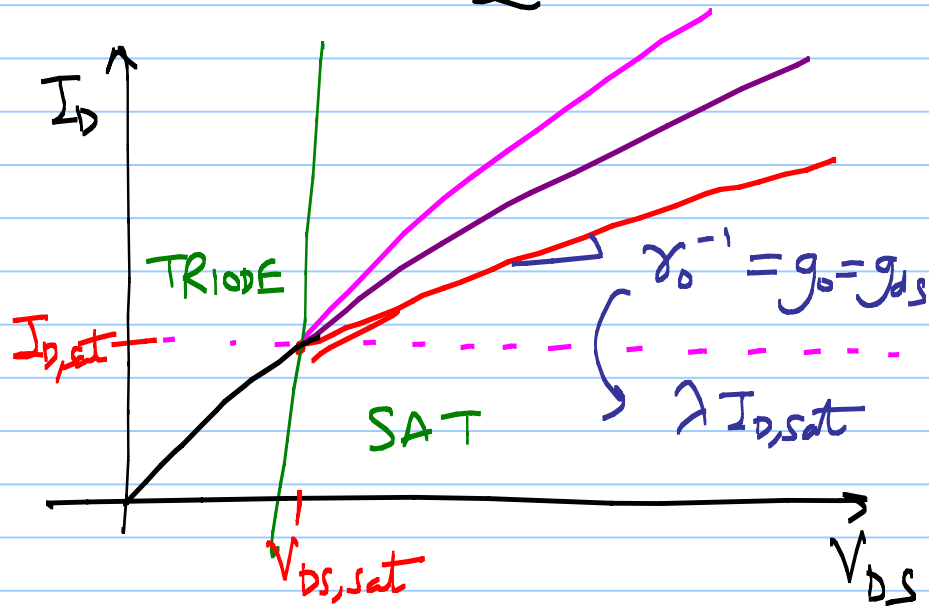
$$I_D = I_{D,sat} + I_{D,sat} \cdot \lambda (V_{DS} - V_{DS,sat})$$

$$I_{D,sat} = \frac{K_n}{2} \frac{W}{L} (V_{GS} - V_{THN})^2$$



$$r_o = \left(\frac{\partial I_D}{\partial V_{DS}} \right)^{-1} = \frac{1}{\lambda I_{D,sat}}$$





$\lambda \uparrow \Rightarrow r_o \downarrow$ output resistance of the MOSFET decreases as the CLM effect increases

Triode: $V_{DS} \ll V_{DS,sat}$

$$I_D = K_n \frac{W}{L}\left[(V_{GS}-V_{THN})V_{DS} - \frac{V_{DS}^2}{2}\right]$$

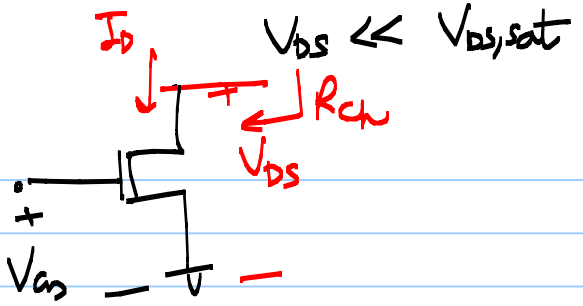
$V_{DS,sat} = V_{GS}-V_{THN}$

deep Triode

$$I_D \approx K_n \frac{W}{L}(V_{GS}-V_{THN})V_{DS}$$

* Linear dependence on V_{DS}
* I_D depends on V_{GS}

$$R_{ch} = \left(\frac{\partial I_D}{\partial V_{DS}}\right)^{-1} = \frac{1}{K_n \frac{W}{L}(V_{GS}-V_{THN})}$$

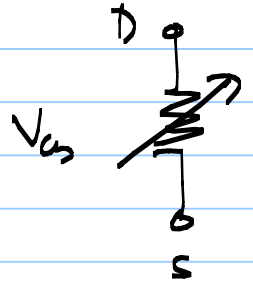


$$R_{ch} = \frac{1}{k_n \frac{W}{L}(V_{GS} - V_{THN})}$$

x for fixed V_{GS} = cnt

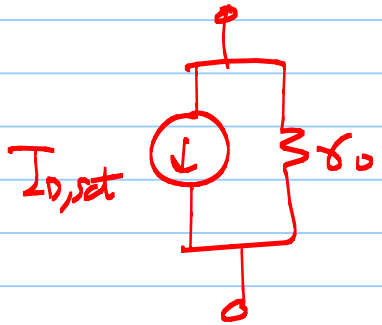
R_{ch} is linear wrt V_{DS}

$$R_{ch} \propto \frac{1}{(V_{GS} - V_{THN})}$$

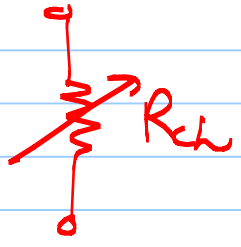


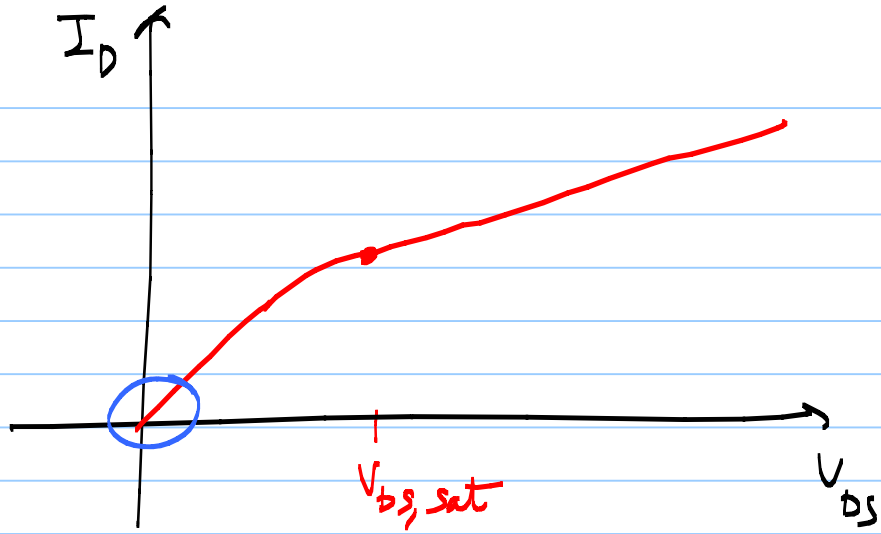
In triode, a MOSFET acts like a resistor, whose resistance is controlled by the gate overdrive voltage

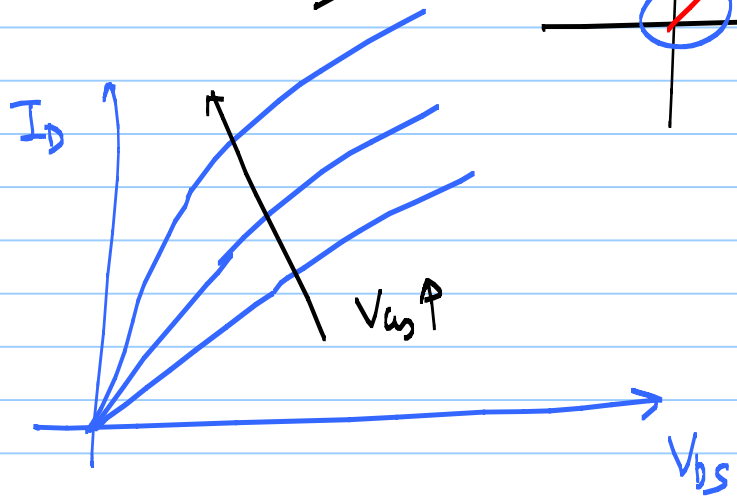
SAT

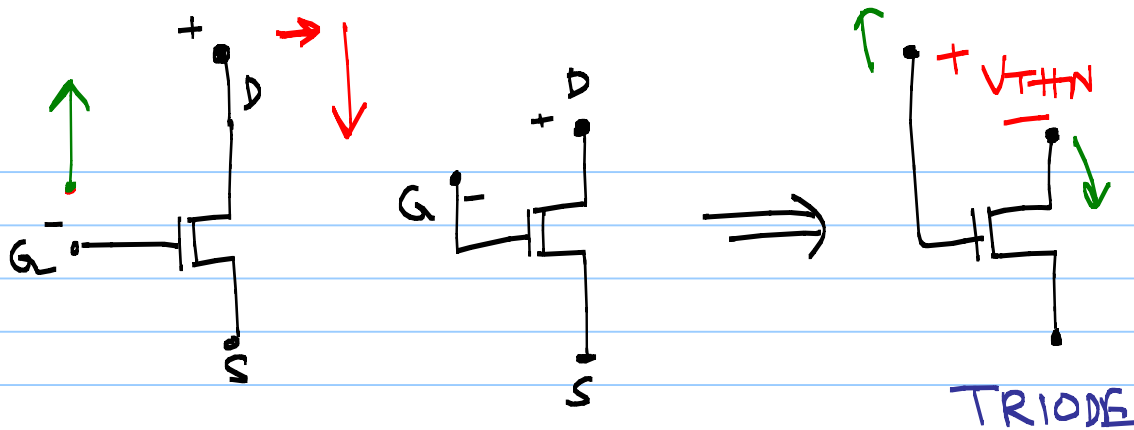


TRIODE









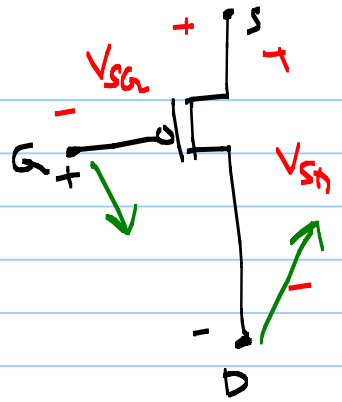
SATURATION

$V_{DS} > V_{DS,sat}$

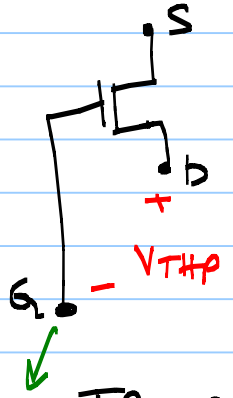
TRIODE

* The NMOS can have the gate at a max of V_{THN} higher than the drain before it triodes.

PMOS



SAT



TRIODE

$$V_{SD} > V_{SD,sat} = V_{SG} - V_{THP}$$

for saturation, Gate can't be lower than the drain by more than V_{THP}.