1. An NMOS transistor is characterized as follows: V_{DS}=0.1V, V_t=1.5V, k'_n= 25 μA/V^2, and W/L = 10. Find the drain current for V_{GS}=0V, 1V, 2V, and 3V.

$$I_D = k'_n \frac{W}{L}(V_{GS}-V_t)(V_{DS})$$

① $v_{GS} > V_t$, v_{DS} very small

$$i_D = k'_n \frac{W}{L}(v_{GS}-V_t)\,v_{DS}$$

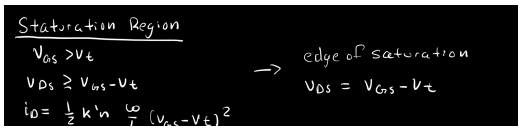
$$r_{DS} = \frac{1}{k'_n \frac{W}{L}(v_{GS}-V_t)}$$

② $v_{GS} > V_t$ v_{DS} is small

$v_{DS} < (v_{GS}-V_t)$

$$i_D = k'_n \frac{W}{L}\left[(v_{GS}-V_t)v_{DS} - \frac{1}{2}v_{DS}^2\right]$$

2. An NMOS transistor is characterized as follows: V_{DS}=3.3V, V_t=1.V, k'_n= 37.5 μA/V^2, and W/L = 10. Find the drain current for V_{GS}=0V, 1V, 2V, and 3V.



Metric Prefix	Symbol	Multiplier (Traditional Notation)	Exponential	Description
Yotta	**Y**	**1,000,000,000,000,000,000,000,000**	**10^{24}**	**Septillion**
Zetta	**Z**	**1,000,000,000,000,000,000,000**	**10^{21}**	**Sextillion**
Exa	**E**	**1,000,000,000,000,000,000**	**10^{18}**	**Quintillion**
Peta	**P**	**1,000,000,000,000,000**	**10^{15}**	**Quadrillion**
Tera	**T**	**1,000,000,000,000**	**10^{12}**	**Trillion**
Giga	**G**	**1,000,000,000**	**10^{9}**	**Billion**
Mega	**M**	**1,000,000**	**10^{6}**	**Million**
kilo	**k**	**1,000**	**10^{3}**	**Thousand**
hecto	h	100	10^{2}	Hundred
deca	da	10	10^{1}	Ten
base	b	1	10^{0}	One
deci	d	1/10	10^{-1}	Tenth
centi	c	1/100	10^{-2}	Hundredth
milli	**m**	**1/1,000**	**10^{-3}**	**Thousandth**
micro	**μ**	**1/1,000,000**	**10^{-6}**	**Millionth**
nano	**n**	**1/1,000,000,000**	**10^{-9}**	**Billionth**
pico	**p**	**1/1,000,000,000,000**	**10^{-12}**	**Trillionth**
femto	**f**	**1/1,000,000,000,000,000**	**10^{-15}**	**Quadrillionth**
atto	**a**	**1/1,000,000,000,000,000,000**	**10^{-18}**	**Quintillionth**
zepto	**z**	**1/1,000,000,000,000,000,000,000**	**10^{-21}**	**Sextillionth**
yocto	**y**	**1/1,000,000,000,000,000,000,000,000**	**10^{-24}**	**Septillionth**

3. Identify the region of operation and the drain current for an NMOS transistor where the k'_n= 25 µA/V2, V_t=1Vand W/L = 10.
   a. V_{GS}=5V and V_{DS}=6V
   b. V_{GS}=0V and V_{DS}=6V
   c. V_{GS}=2V and V_{DS}=-0.5V

a)

(Triode / sat?)

Know
$V_{GS} = 0 - V_S$
$V_{DS} = 0.2 - V_S$

$V_{DS} \geq V_{GS} - V_t$
$0.2 - V_S \geq -V_S - .5$
↳ assume ≥ → sat. operation

→ Saturation

Saturation Region
$V_{GS} > V_t$
$V_{DS} \geq V_{GS} - V_t$
$i_D = \frac{1}{2} k'_n \frac{W}{L} (V_{GS} - V_t)^2$

→ edge of saturation
$V_{DS} = V_{GS} - V_t$

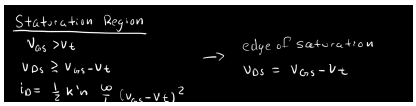
b)

Since $V_{GS} < V_t$; $I_D = 0$

c)

Since $V_{DS} < 0$... $I_D = 0$
Cutoff

4. An NMOS transistor has V_t=0.8V, k'^n= 0.05 mA/V^2, and W/L = 2. The device is biased at V^{GS}=2.5 V. Calculate the drain current and the resistance r_O for V_{DS}=2V and 10V for
   a. λ=0
   b. λ=0.02
   c. V_A=35V



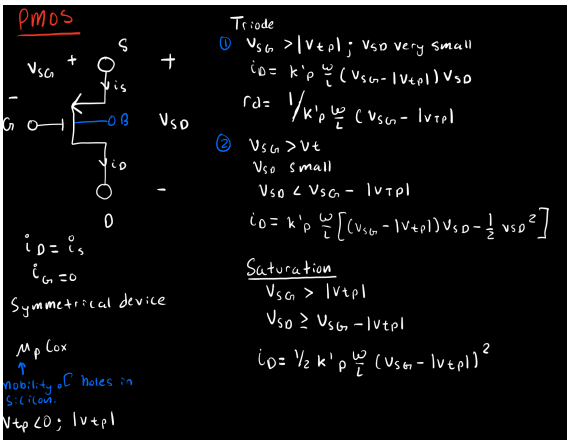
Saturation region

Saturation region

c)

5. A PMOS transistor has k'_p= 0.1 mA/V^2, W/L = 2, V_t= -2V and V_{SG}= 3V. Find the region of operation and the drain current for:
   a. V_{SD}=0.5V
   b. V_{SD}=2V
   c. V_{SD}=5V

a).

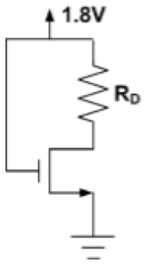


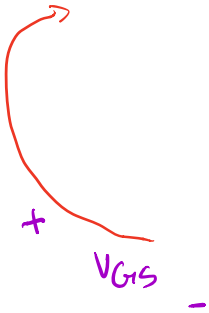
-> Triode Region

b) $V_{SD} = 2$
-> Saturation region

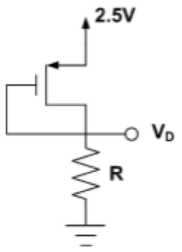
c) $V_{SD} = 5$
-> Saturation

6. Consider the following NMOS circuit where V_t=0.5V, k'_n= 0.4 mA/V2, and W/L = 5. If the circuit operates at the edge of saturation with a drain current of 1mA, find the resistor, R_D.





7. Consider the following PMOS circuit where V_t=-0.6V, k'_p= 250 µA/V^2, and L = 0.25µm. find the values required for W and R such that the drain current is 0.8mA and the drain voltage is 1.5V.



8. Find the labeled voltages and currents in the following circuit where V_{tn} =+1V, V_{tp} = -1V, k'_n= 20 µA/V^2, k'_p= 8 µA/V^2 and W/L = 3 (for both n and p-type transistors).