Tutorial 7 -MOS transistors

Problem 1:

Figure 1 shows the NMOS and PMOS devices with drain, source and gate ports annotated.

Determine the mode of operation (Saturation, Triode, Cut-off) as well as the drain current I_D for each of the biasing configurations given bellow. Use the following transistor data:
NMOS: K_n'=60μA/V^2, V_{TO}=0.7V, λ=0.1 V^{-1}
PMOS: K_p'=20μA/V^2, V_{TO}= – 0.8V, λ=–0.1 V^{-1}

Assume that W/L = 1 for both transistors.

Biasing configurations:
(a). NMOS: V_{GS}=3.3V; V_{DS}=3.3V. PMOS: V_{GS}=–0.5V; V_{DS}=–1.5V
(b). NMOS: V_{GS}=3.3V; V_{DS}=2.2V. PMOS: V_{GS}=–3.3V; V_{DS}=–2.6V
(c). NMOS: V_{GS}=0.6V; V_{DS}=0.1V. PMOS: V_{GS}=–3.3V; V_{DS}=–0.5V

Fig.1 NMOS (left) and PMOS (right) transistors notations.

Problem 2:
Assume no body effect or channel length modulation
Various NMOS and PMOS transistors are measured in operation, as shown in the table below. For each transistor, find the value of $\mu C_{ox}W/L$ and V_t that apply and complete the table with V in Volts, I in μA, and $\mu C_{ox}W/L$ in μA/V^2.

Case	Transistor	V_S	V_G	V_D	I_D	Type	Mode	$\mu C_{ox}W/L$	V_t
a	1	0	2	5	100				
	1	0	3	5	400				
b	2	5	3	-4.5	50				
	2	5	2	-0.5	450				
c	3	5	3	4	200				
	3	5	2	0	800				
d	4	-2	0	0	72				
	4	-4	0	-3	270				

Problem 3:

a) What is the operating mode of the two transistors represented in Fig.a and b if we assume that the voltage V_x varies from 0 to V_{DD}?
b) For $V_x=(V_{DD}/2)=2.5V$, what will be the value of the current I_{DS} for both transistors?

Use the following transistor data:
NMOS: $K_n'=60\mu A/V^2$, $V_{TO}=0.7V$, $\lambda=0.1\ V^{-1}$;
PMOS: $K_p'=20\mu A/V^2$, $V_{TO}=-0.8V$, $\lambda=-0.1\ V^{-1}$
Assume that W/L = 1 for both transistors.

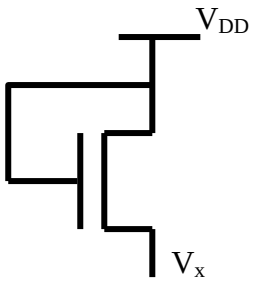

Fig.a

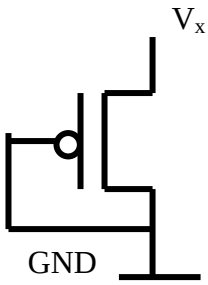

Fig.b

Problem 4:

Consider the circuit configuration of Figure 2. $K_p'=5.4\ \mu A/V^2$ and $V_{thp}=-0.739V$

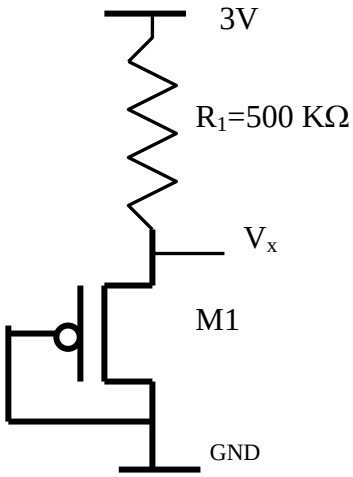

Fig2.

a) Assuming $V_x > -V_{thp}$; find out the operating mode of the transistor and deduce the expression of the current I_{DS}.
b) Deduce the expression of the voltage V_x (Assume that the channel length modulation coefficient λ is zero. $\lambda=0$).
c) Determine the required width of the transistor (for $L=1.2\mu m$) such that $V_x=1.5V$.