Please submit your solutions to Moodle by Tuesday, 17.10.2023, 23:55.

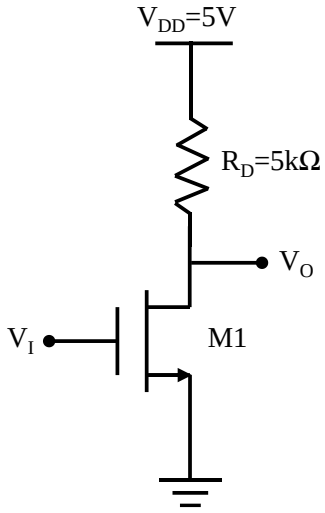
Homework #1

1. Draw the cross section of a n channel enhancement MOSFET and explain the I_D-V_{DS} relation for

- **a.** $V_{GS} < V_{th}$
- **b.** $V_{GS} > V_{th}$, and for small V_{DS} voltages
- **c.** $V_{GS} > V_{th}$, and for large V_{DS} voltages

You need to explain why there is no current flowing from Gate, Drain, and Source terminals to the substrate.

2.



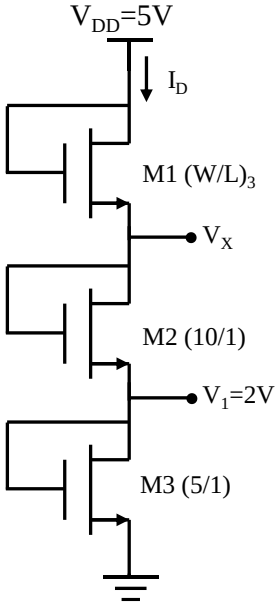
For the circuit on the left V_{th}=1V, and K_N=0.2mA/V^2

Find and plot V_O vs V_I for $0 < V_I < 5$V.

You don't have to calculate V_O for all the V_I values, but your plot should reflect the actual behavior. Label the states of M1 in your plot. Find the value of V_I when the M1 state changes from TRIODE to SATURATION.

It is not required but you can write a program to plot V_O vs V_I for all values of V_I.

3.



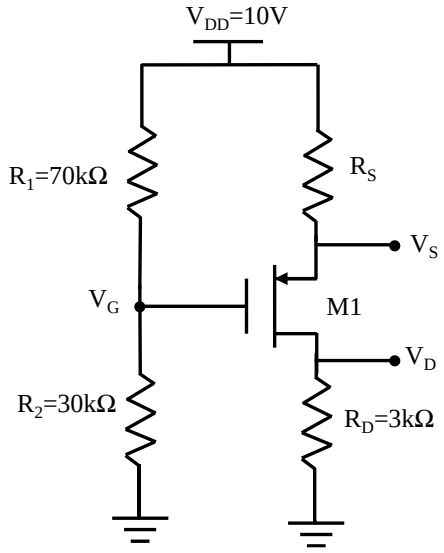
For the circuit on the left $k_N'/2$=100μA/V^2, Vth=1V for all transistors.

(W/L) ratio of M2 and M3, and V_1=2V are given.

Find V_X, $(W/L)_3$, and I_D.

Verify the transistor states.

4.



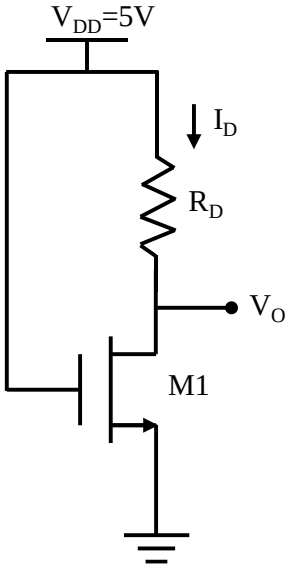
For the pMOS circuit on the left, K_p=0.25mA/V^2, and V_{tp}=-1V

Find the Q point (V_{SD}, I_D) for

- **a.** R_S=5kΩ
- **b.** R_S=1kΩ

Verify the transistor state for both cases.

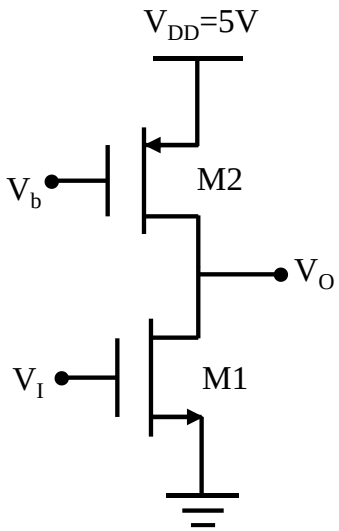
5.



For the nMOS circuit on the left, K_N=0.2mA/V^2, and Vth=1.5V

- **a.** Write the condition in terms of I_D and other circuit parameter for M1 to stay in SATURATION (no numerical values here). Explain the state of M1 as I increase the value of R_D using the load line approach.
- **b.** Find the range of R_D to keep M1 in SATURATION.

6.



For the circuit on the left, K_N=K_P, V_{tn}=1V, V_{tp}=-1V

Find the range of bias voltage V_b, to keep M1 in SATURATION and M2 in TRIODE for

- **a.** V_I=2V
- **b.** V_I=3V