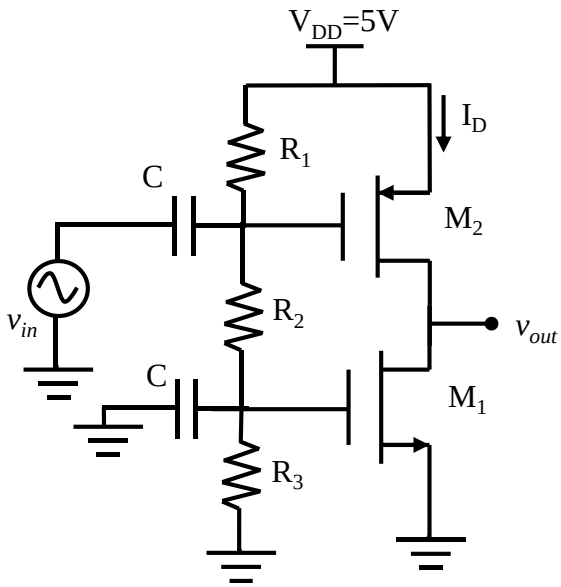
Please submit your solutions to Moodle by Sunday, 29.10.2023, 23:55.

Homework #2

1.

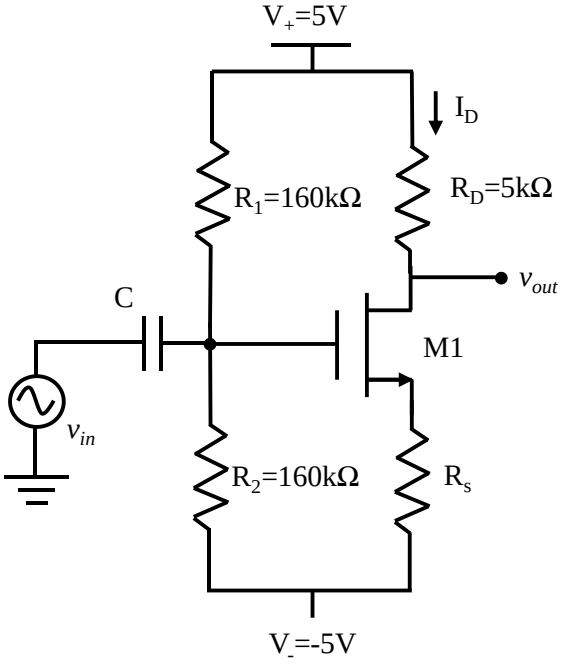


For the circuit on the left
$R_1=R_3=200k\Omega$, $R_2=100k\Omega$
$V_{tn}=1V$, $V_{tp}=-1V$
$K_N=K_P=0.25mA/V^2$
$\lambda_1=0.02V^{-1}$, $\lambda_2=0.01V^{-1}$

a. Find the DC operating points of M1 and M2 and calculate the small signal parameters, i.e. I_D, V_{DS}, g_m and r_o.
b. Find the small signal gain of the circuit, $A_V=v_{out}/v_{in}$.
c. Find small signal R_{in} and R_{out}.

You should decide on whether to use λ's in the DC analysis or not.

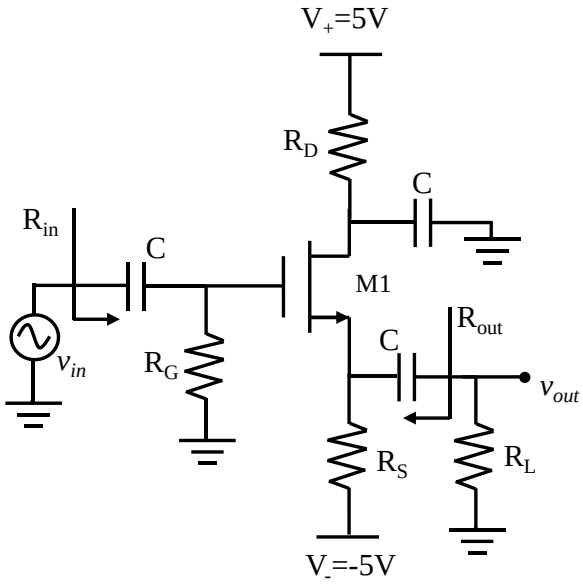
2.



For the circuit on the left $K_N=0.25mA/V^2$, $V_{TN}=1V$. $\lambda=0.01V^{-1}$.

a. Find the value of R_S in order to have 0V DC at the v_{out} node. You can assume $\lambda=0$.
b. Find the small signal gain by assuming $\lambda=0$.
c. Find the small signal gain without ignoring r_o and show that your result converges to part b for $\lambda=0$. You will need to do some algebra for this part. You don't need to repeat part a.
d. Find R_{in} and R_{out} without ignoring r_o.

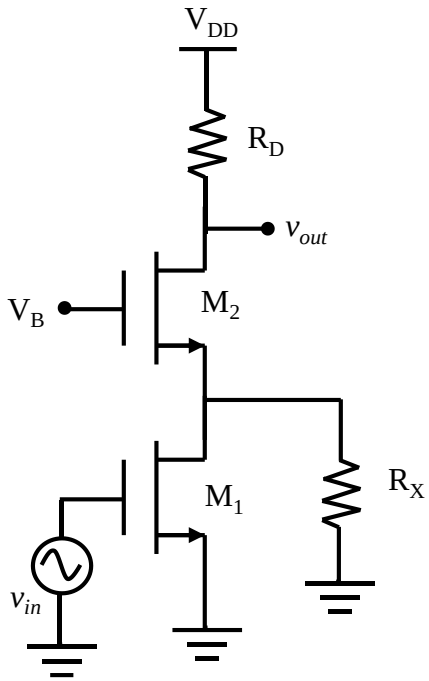
3.



For the circuit on the left:
R_G=5MΩ, K_N=0.5mA/V^2, V_{TN}=1V, λ=0.01V^{-1}

a. Assuming M1 is in SAT, find R_S and R_D such that I_{DQ}=0.2mA and V_{DQ}=1V. Assume λ=0 for this part.
b. Find the open circuit voltage gain, $A_{VOC}=v_{out}/v_{in}$ assuming $R_L=\infty$.
c. Find R_{in} and R_{out}.
d. Find $A_V=v_{out}/v_{in}$ for R_L=10kΩ using your results in part b and c. Do not rederive A_V. You will need to use the black box model of the amplifier.

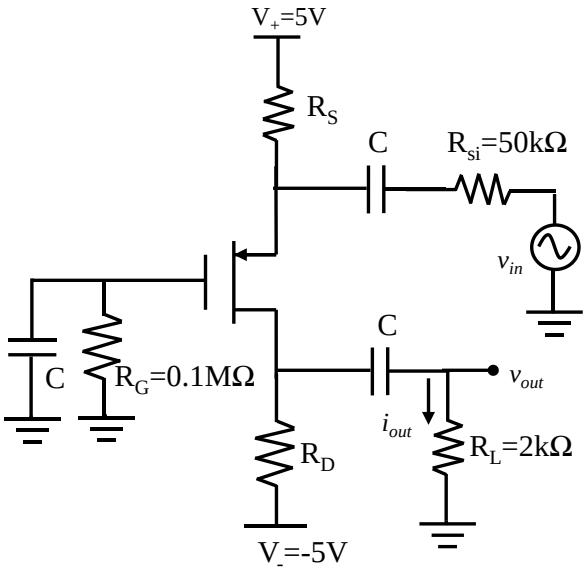
4.



Assume that M1 and M2 are biased in SAT for the circuit shown on the left and λ=0 for both transistors.

Calculate the voltage gain (v_{out}/v_{in}) in terms of transistor g_m's and
circuit parameters.

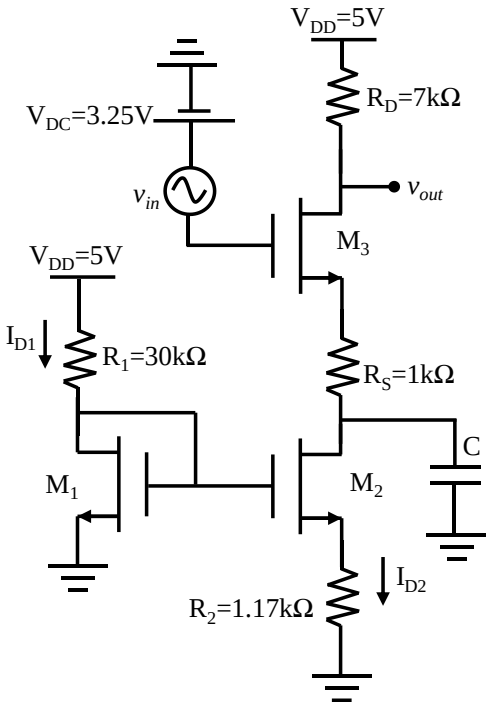
5.



For the circuit on the left, V_{tp}=-1V, K_P=0.5mA/V^2, λ=0.

a. Find the value of R_S and R_D such that I_{DQ}=0.5mA and V_{SDQ}=5V.
b. Find the input (R_{in}) and output resistance (R_{out}).
c. Find the output current i_{out} if v_{in}=0.5mV cos(ωt).

6.



For the circuit shown on the left,
K_{N1}=0.1 mA/V^2, K_{N2}=0.5 mA/V^2,
K_{N3}=1 mA/V^2
Vth=1V and λ=0 for all transistors.

a. Find I_{D1}, I_{D2} and verify the states of all transistors. Find all the DC node voltages on the circuit.

b. Find the AC small signal gain, A_V=v_{out} / v_{in}. Find the symbolic answer first.