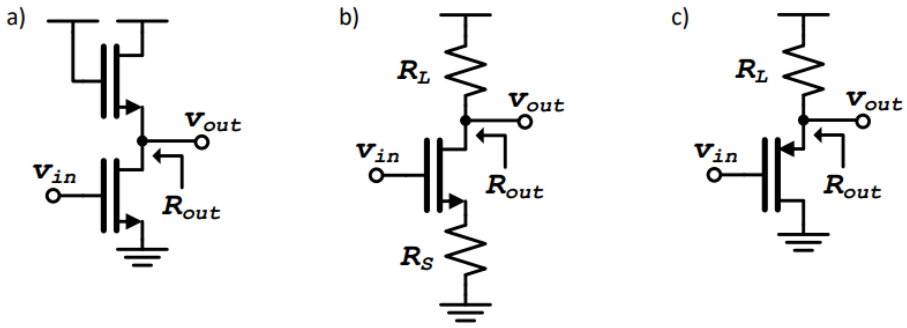
Faculty of Engineering – Cairo University
Electronics and Electrical Communications Department
EECE2020 – Electronics II
Problem Set # 3

Unless otherwise mentioned, assume the following: $k_n' = \mu_n C_{ox} = 200\ \mu A/V^2$, $k_p' = \mu_p C_{ox} = 100\ \mu A/V^2$, and $V_{TH} = 0.4\ V$ for NMOS devices and −0.4 V for PMOS devices.

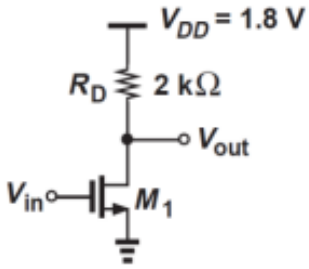
Problem 1: Practice solving these circuits "by inspection." For each of the following circuits, write the expression for gain ($A_v = v_{out}/v_{in}$) and Rout. It is ok to keep parallel combinations of resistors in the form ($R_1||R_2$). For simplicity, assume that gm and ro are identical for all devices, and ignore ro when appropriate. Assume RL and RS << ro.



Problem 2: The "intrinsic gain" of a MOSFET operating in saturation is defined as $g_m r_o$. Derive an expression for the intrinsic gain and plot the result as a function of ID for a constant W and L. Assume VDS is constant.

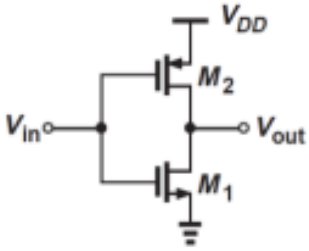
Problem 3: Show that the small-signal equivalent of a transistor whose drain and gate are shorted is a resistance and find its value.

Problem 4: In the common-source amplifier shown, W/L=30 and λ=0. Calculate the gate voltage that yields a drain current of 0.5mA. verify that the transistor is in saturation. What is the gain of the stage?

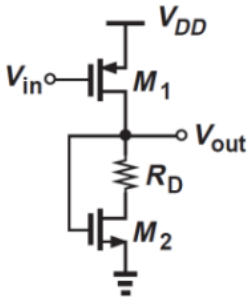


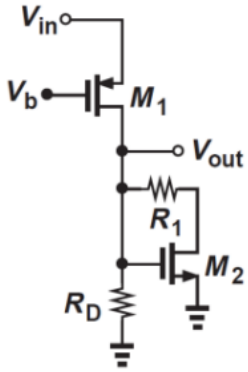
Problem 5: Consider the circuit depicted in the figure shown, where M1 and M2 operate in saturation and exhibit channel length modulation coefficients λn and λp, respectively.

a) Construct the small-signal equivalent circuit and explain why M1 and M2 appear in "parallel."
b) Determine the small-signal voltage gain of the circuit.

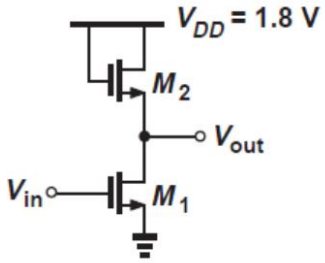


Problem 6: Construct the small-signal model of both circuits shown below. Calculate the voltage gain. Assume all transistors are in saturation region. Consider channel length modulation.

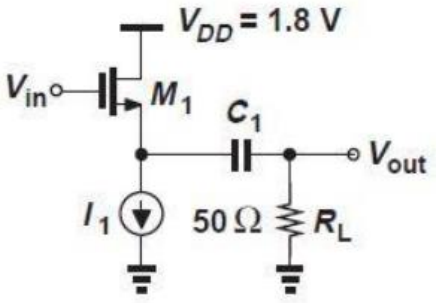




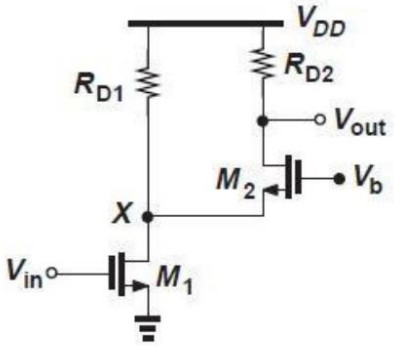
Problem 7: Design for a voltage gain of 5, get $\left(\frac{W}{L}\right)_1$ if $\left(\frac{W}{L}\right)_2$=2/0.18. Neglect channel length modulation. What is the maximum allowable current for M1 to remain in saturation.



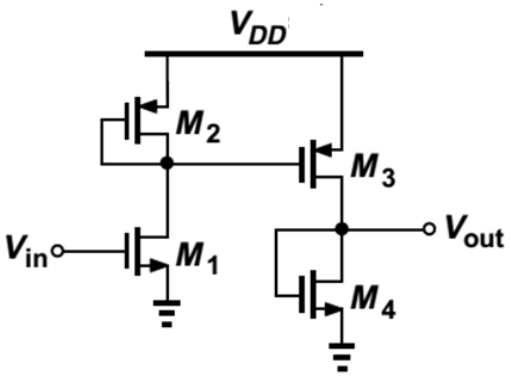
Problem 8: For a power budget of 3mW, $\lambda = 0$ *and* $C1$ is very large, get the required W/L for a source of follower of gain 0.8.



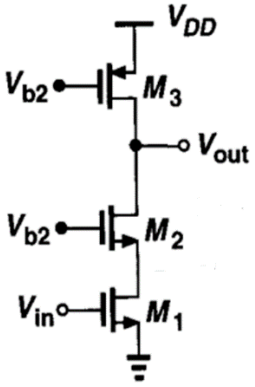
Problem 9: For each of the amplifiers shown below, draw the small signal model and calculate the voltage gain and output impedance in terms of the small signal parameters. Ignore ro when appropriate (R << ro).



(a)



(b)



(c)