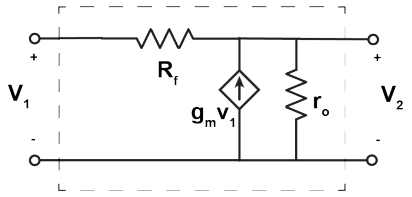
EE 332 Circuits and Devices II Autumn 2022

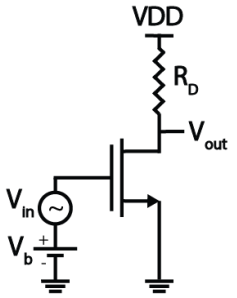
Homework 2 Due: Oct. 21 (11:59pm)

1. For the *two-port network* shown below: (All the answers should be in terms of g_m, r_o, R_f, and R_s). In this problem, the two ports at V_1 are the input and the two ports at V_2 are the output.



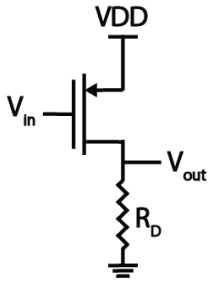
a. Write down KVL/KCL equations to relate V_2 and V_1 and find the gain (V_2/V_1).
b. Find the input impedance.
c. Assuming that there is a voltage source with source resistance of Rs at the input, find the output impedance.

2. For the following circuit with an NMOS device assuming $\lambda = 0.1V^{-1}, \mu_n C_{ox} = \frac{200\mu A}{V^2}, V_{th} = 0.4V, \frac{W}{L} = 50, L = 65nm, R_D = 500\Omega, V_{DD} = 1V, V_b = 0.8V$:



a. Find the bias point and determine the operation region of NMOS device.
b. Find small-signal parameters g_m and r_o for the NMOS.
c. Draw the small-signal model for the NMOS (you can ignore parasitic capacitances).
d. Draw the small-signal model for the full circuit (you can ignore parasitic capacitances).
e. Write down KVL/KCL equations to find the small-signal gain ($\frac{v_{out}}{v_{in}}$).
f. Find the small-signal gain (questions e and f can be thought of as one question, but make sure to show all your equations and work when finding the small signal gain).

3. Assume a basic common-source amplifier with PMOS input (operating in saturation) and R_D as the load.



a. Draw the small-signal model, and calculate gain, input, and output impedances. ($\lambda \neq 0$). Do this parametrically (as in, your answer should be a function of variables such as g_m and r_o).
b. Suppose VDD = 1V, V_{th} = -0.4V, V_{IN} (input bias) = VDD/2, what's the output voltage swing range ($V_{out,min}, V_{out,max}$)?
c. With voltages from part (b), if $\lambda = 0.1V^{-1}, \mu_p C_{ox} = \frac{50\mu A}{V^2}, R_D = 20k\Omega$, what should be W/L to achieve a small signal gain of 20?