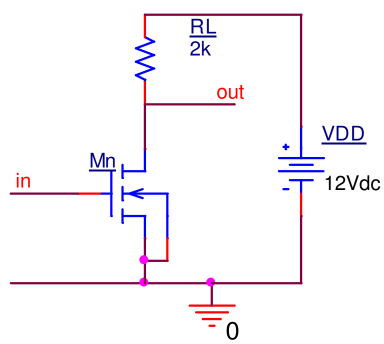
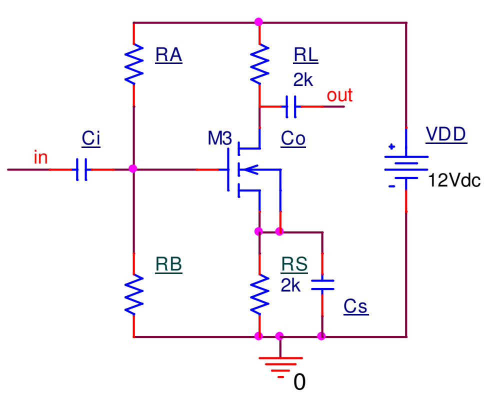
File: G/coursesS19/303/303S19Midtrm.doc RWN 04/03/19 [Prob 2 corrected]
ENEE 303 Spring 2019 – Midterm Exam [4 problems].

Open book open notes but only approved computers; 100 points total (75 minutes)
Your signature insures that the work submitted is solely your own. Good luck
For NMOS transistors assume $k=4mA/V^2 = (KP/2)(W/L)$, VTO = 1V, $\lambda=0$; for PMOS assume complementary to NMOS except $k=2mA/V^2$
For bipolar assume $\beta=100$, V_A=Early voltage = 200V

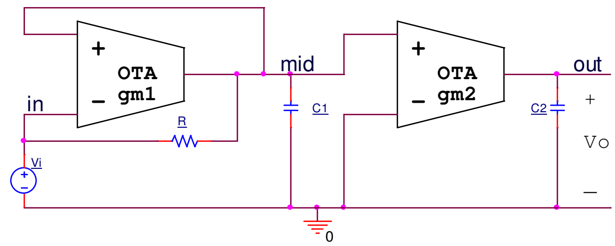
1. (20 points 10 minutes; NMOS inverter)
   For the following circuit determine the input voltage Vtr for which when vin>Vtr the NMOS transistor is in the triode region.



2. (35 points, 20 min; NMOS bias & gain)
   For the following NMOS amplifier assume RL=RS=2kOhm and RA need not = RB (and not necessarily large).
   a) For I_D=1mA find the Q point (bias) values for V_{GS} and V_{DS} and check that the transistor is in saturation
   b) Draw the mid-band gain small signal equivalent circuit and give the mid-band voltage gain $Av = v_{out}/v_{in}$ (where voltages are measured with respect to ground and the capacitors are assumed shorts) [include RA & RB].



3. (25 points, 20 min; OTA circuit gain and ODE)



a) For this circuit give the voltage transfer function $A_v(s)$.
b) Give the differential equation relating $v_o(t)$ to $v_i(t)$

4. (20 points 10 minutes; Small signal parameters)
The FIN-FET is a new transistor being considered for quantum systems. An N-type FIN-FET with n fins has the same circuit symbol and is like an NMOS (with no gate current and bulk tied to source) but has the n-power law (n=number of fins, any positive real n but normally an integer)

Off: $i_D=0$ for $v_{GS}<Vth$

And for $v_{GS}\geq Vth$:

Saturation: $i_D=k(v_{GS}-Vth)^{(n)}(1+\lambda v_{DS})$ for $v_{DS}\geq(v_{GS}-Vth)$

Triode: $i_D=k([2(Vgs-Vth)^{(n/2)}(v_{DS}^{(n/2)})]-v_{DS}^{(n)})(1+\lambda vDS)$ for $v_{DS}\leq(v_{GS}-Vth)$

a) Show that there is a number of fins, n, for which the FIN-FET behaves like an NMOS transistor
b) For any positive real n, assuming a FIN-FET is biased to be in saturation, find its gm and go in terms of Q point values and draw low frequency equivalent circuit.