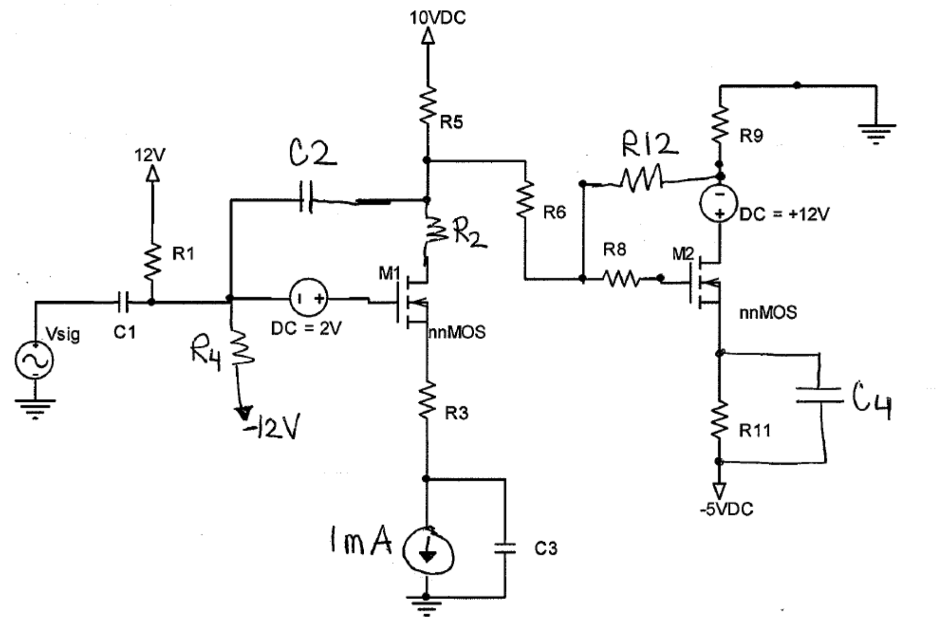
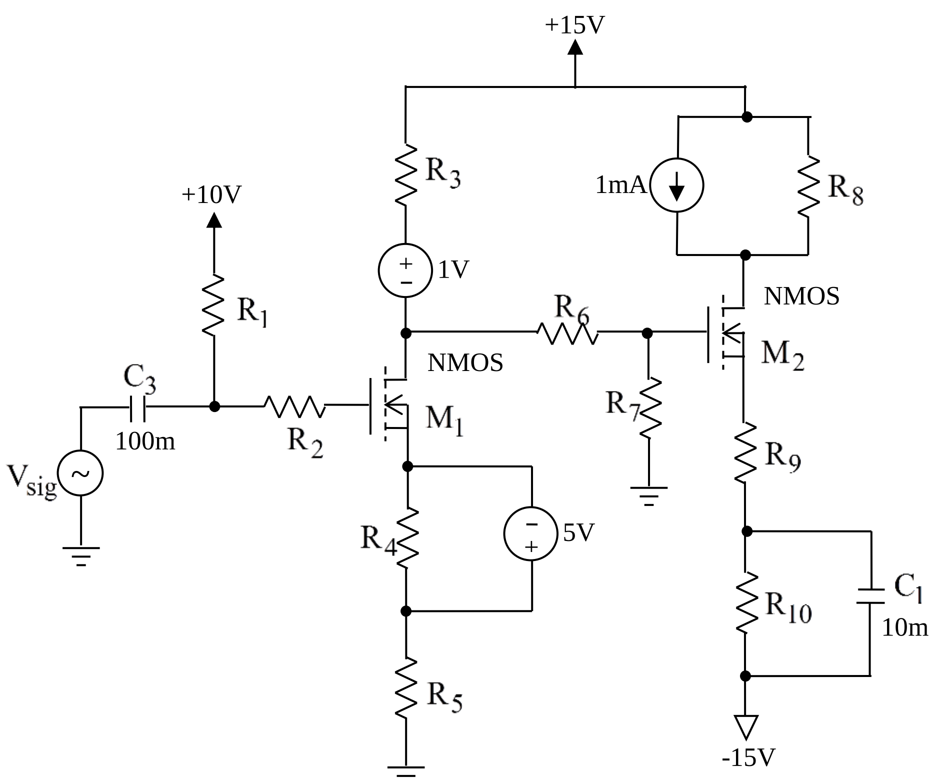
ECE2280 **Homework #8** **Spring 2014**

1. For the circuit shown below, **draw** the AC small-signal equivalent circuit(use hybrid-π or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1}, v_{gs2}, r_{o1}, etc.). $\lambda \neq 0$ for all transistors.(i.e. draw the small-signal with r_o included). v_{sig}=0.005sin(20t) AC. Draw the small-signal equivalent circuit **WITH** capacitors shown.



2. For the circuit shown below, **draw** the AC small-signal equivalent circuit(use hybrid-π or model T). Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1}, v_{gs2}, etc.). **λ=0.5** for all transistors. Note that this will put a resistance (label it r_{o1} or r_{o2}) in parallel with the dependent source of the hybrid-π or model T. Let v_{sig}=0.005sin(20t) AC. Assume all capacitors are **SHORT** for the AC circuit.



3. Use: V_t=2V

$k_n'(W/L)=3mA/V^2$

V_{sig} is an AC source

Transistor 1 has DC values: V_{GS}=4V, I_D=6mA

Transistor 2 has DC values: V_{GS}=5.3V, I_D=16.7mA

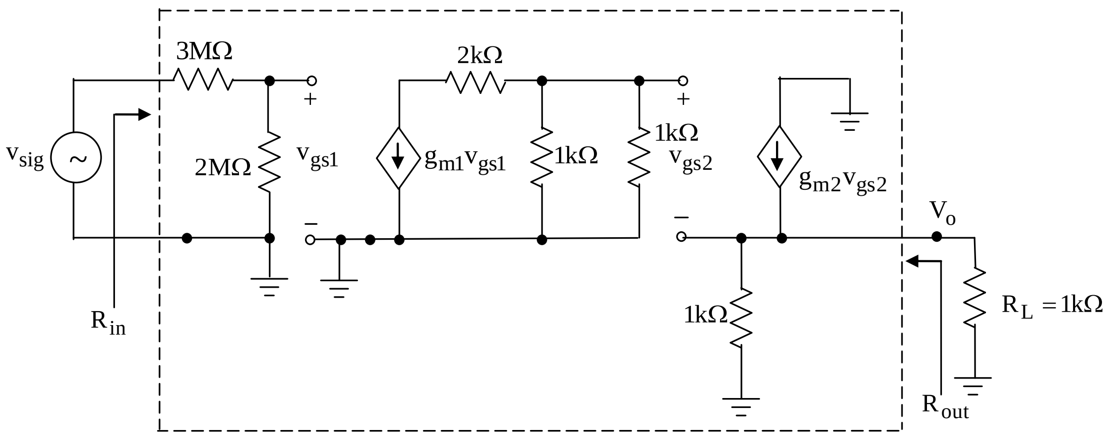
λ=0 (for all transistors)

For the following hybrid-π equivalent circuit, find the following values:

(a) R_{in} (input resistance –ignore the input source, Vsig)

(b) R_{out} (output resistance-ignore R_L{no load is connected})

(c) midband gain, $\frac{Vo}{Vsig}$

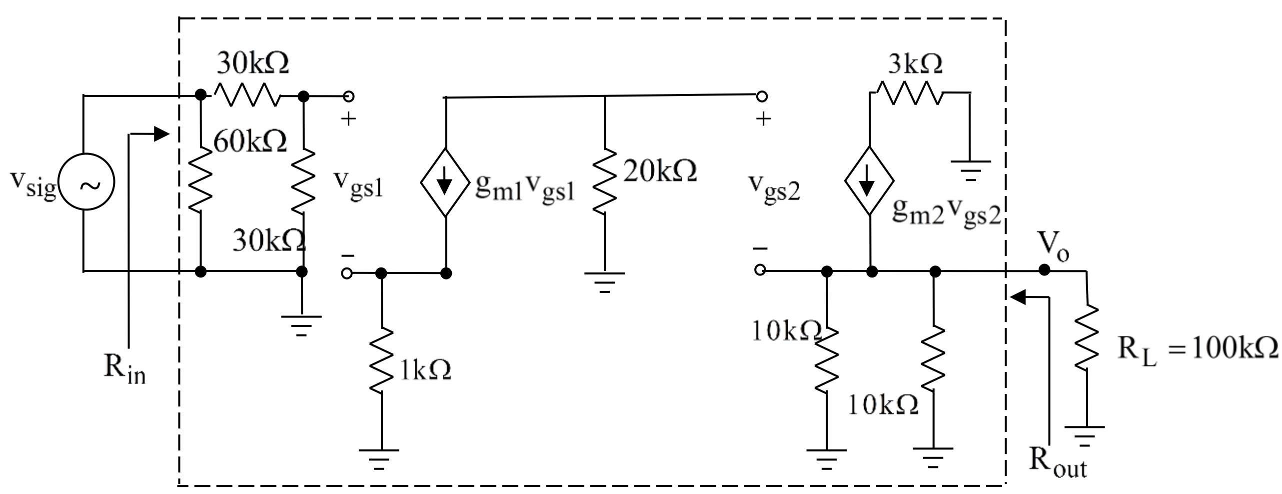


4. Let V_t=1V, $k_n'(W/L)=1mA/V^2$, V_{sig} is an AC source. Transistor 1 has DC values: V_{GS}=3V, I_D=2mA. Transistor 2 has DC values: V_{GS}=5V, I_D=8mA. λ=0 (for all transistors) and assume all transistors are saturated. For the following hybrid-π equivalent circuit, find the following values:

(a) R_{in} (input resistance –ignore the input source, Vsig)

(b) R_{out} (output resistance-ignore R_L{no load is connected})

(c) ideal midband gain, $\frac{Vo}{Vsig}$



5. (a) Draw the hybrid-π circuit

(b) Find the gain $\frac{V_o}{V_I}$ (V_I is an AC source)

(c) Find Rin (node to right of capacitor to ground)

(d) Find Rout (node to left of capacitor to ground)

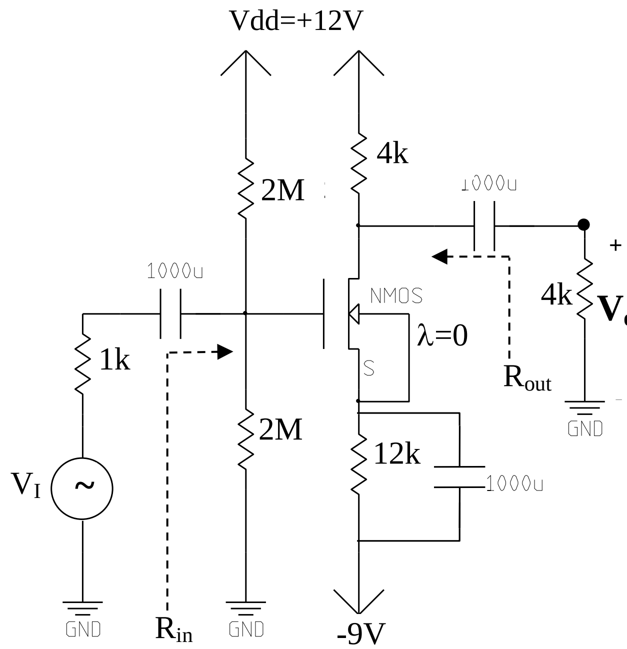
Given:

I_D=1mA and the transistor is saturated

V_t=2V

$k_n'(W/L)$=2mA/V^2

Assume that the capacitors act as closed for the AC analysis.



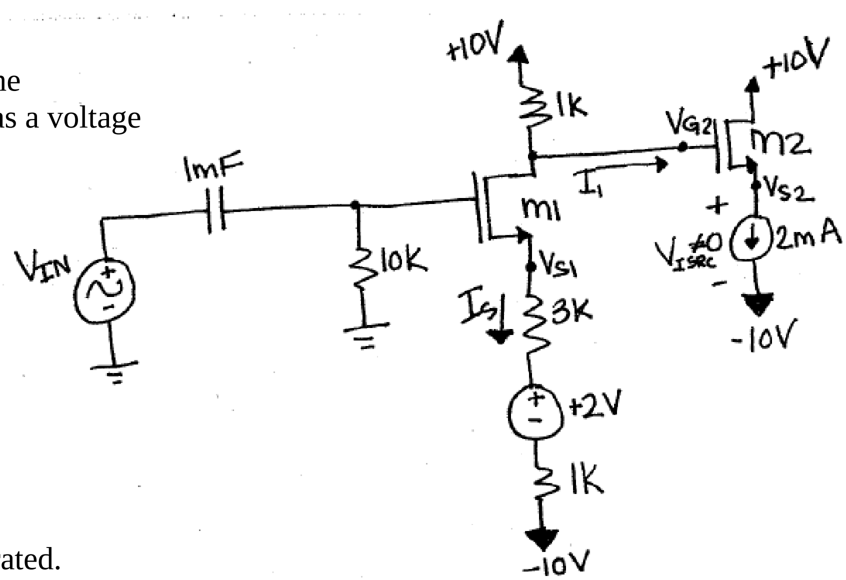
6. **Use:** **V_t=1V**

$k_n'(W/L)$=222μA/V^2

λ=0

V_{IN} = 3+0.002sin(20t)

For DC analysis, assume that the capacitors act as an open. The current source is not ideal and has a voltage drop across it.



(a) Solve for the DC currents:

a. I_1
b. I_S

(b) Solve for the DC voltages:

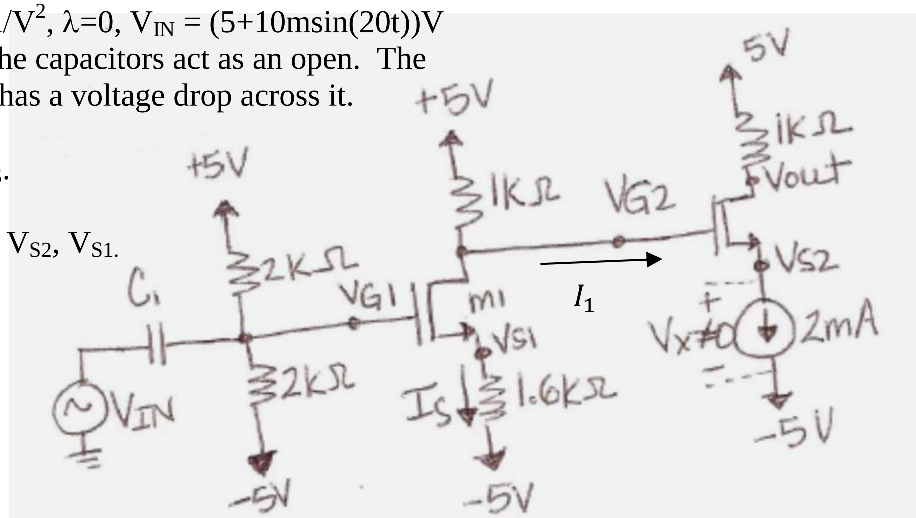
a. V_{G2}
b. V_{S2}
c. V_{S1}

(c) Verify that transistor M2 is saturated.

(d) State the DC bias point for transistor M1.

(e) Assuming that the transistor amplification is V_{S2}/V_I = -4V/V. Assume the input frequency is operating within the circuits operating range. What is the **total** (AC and DC) instantaneous output for V_{S2} using the V_{IN} value stated above.

7. Use: V_t=1V, $k_n'(W/L)$=1mA/V^2, λ=0, V_{IN} = (5+10msin(20t))V
For DC analysis, assume that the capacitors act as an open. The current source is not ideal and has a voltage drop across it.



(a) Solve for the DC currents I_1, I_S.

(b) Solve for the DC voltages V_{G2}, V_{S2}, V_{S1}.

(c) Verify that transistor M2 is saturated.

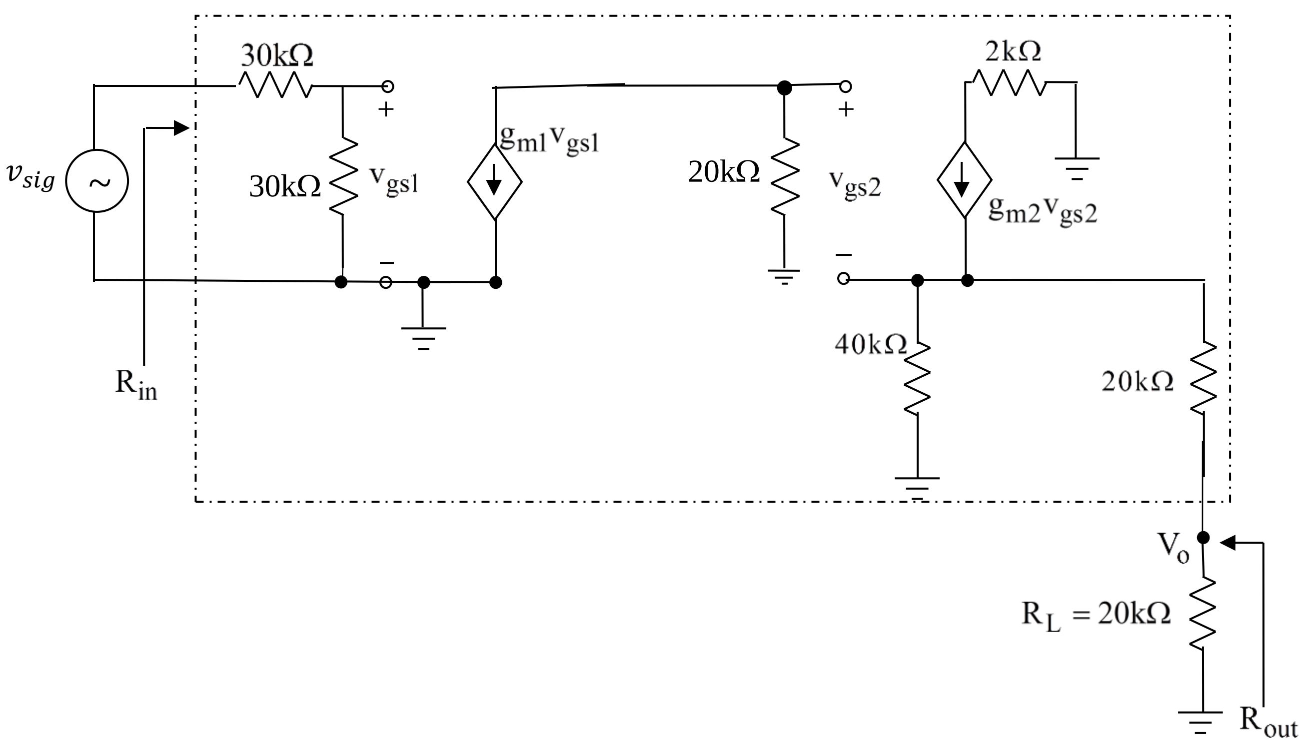
(d) State the DC bias point for transistor M1.

(e) Assuming that the transistor amplification is V_{out}/V_{IN} = +5V/V. Assume the input frequency is operating within the circuits operating range. Assume that the amplification does not pull the transistors out of saturation. Draw a rough sketch of the **total instantaneous value** seen at V_{out} using the V_{IN} value stated above.

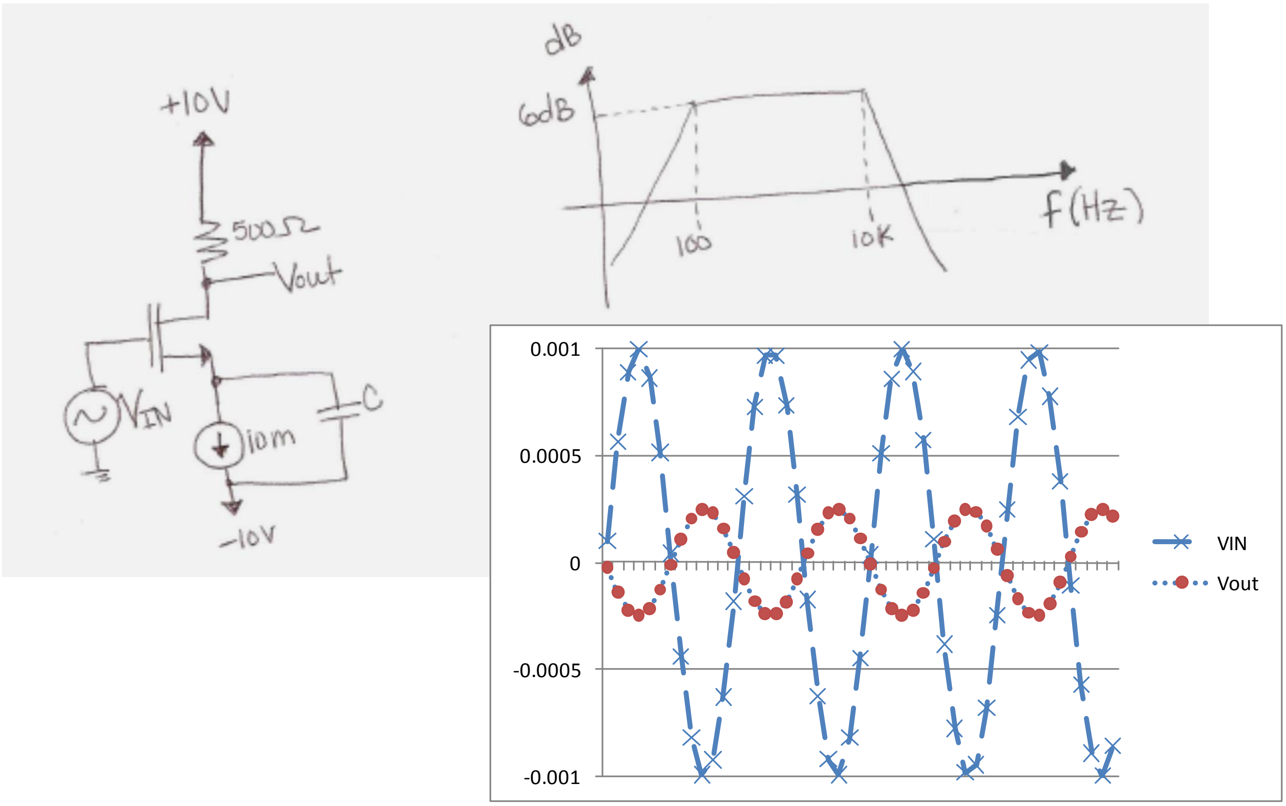
8. V_t=1V, $k_n'(W/L)$=10mA/V^2, V_{sig} is an AC source, λ=0 and assume all transistors are saturated.
Transistor 1 has DC values: V_{GS}=9V, I_D=3.2A
Transistor 2 has DC values: V_{GS}=1.18V, I_D=162µA

For the following hybrid-π equivalent circuit, find the following values:

a. R_{in} (input resistance –ignore the input source, Vsig)
b. R_{out} (output resistance-**ignore** R_L })
c. Find the ideal overall midband gain, $\frac{V_o}{v_{sig}}$ (make sure to include R_L).



9. Let V_t=2V, λ=0, k_n'(W/L)=1mA/V^2, V_{IN} = 5+1msin(ωt). This amplifier was designed to achieve an overall gain of -2V/V. The magnitude Bode plot of the amplifier is shown below. An AC graph(DC is removed) of Vin and Vout is shown for an input frequency of 100kHz. Why is the output peak not 2mV?



10. Let V_t=2V, λ=0, k_n'(W/L)=2mA/V^2, V_{IN} = 5+50msin(ωt). Assume that the capacitor acts as an open for DC operation and a short for AC operation. Does this circuit operate as a **linear** AC amplifier? If so, what is the gain, $\frac{Vout}{Vin}$, of the following circuit? If not, explain why.