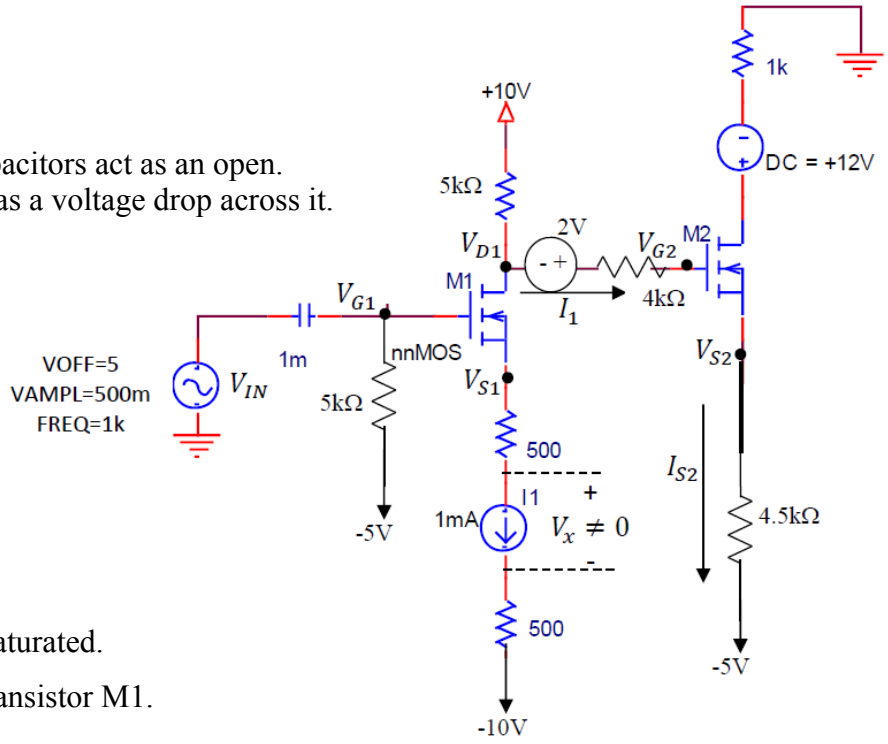
ECE2280 **Homework #10**

1. **Use:** V_t=1V
   k_n'(W/L)=1mA/V^2
   λ=0

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_{S2}

(b) Solve for the DC voltages:

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

(c) Verify that transistor M2 is saturated.

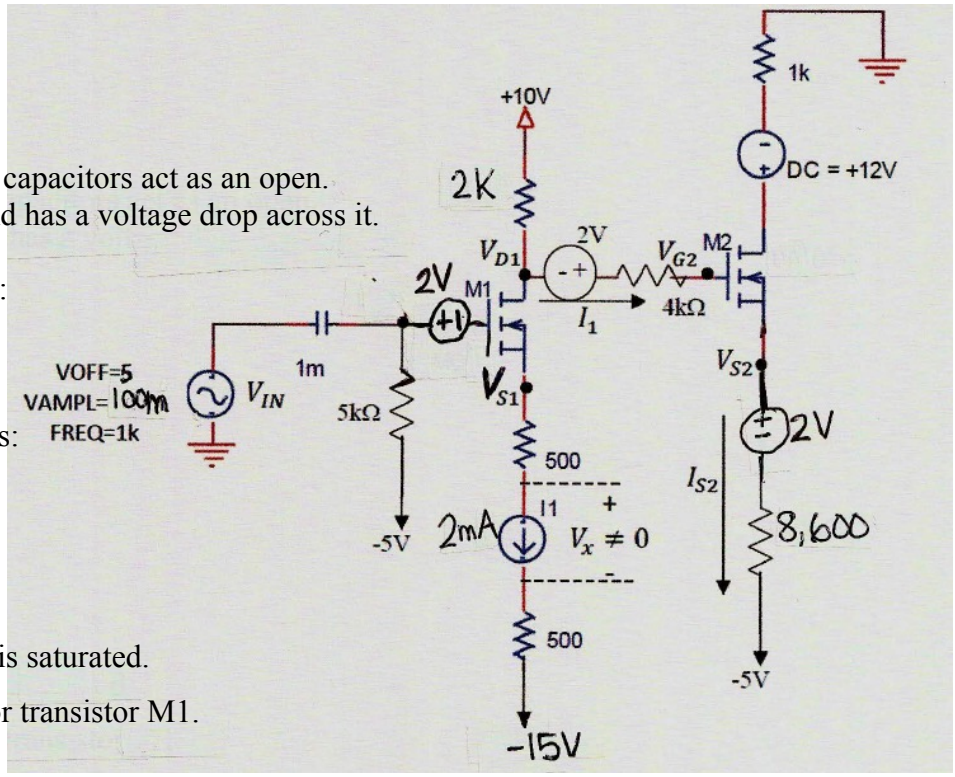
(d) State the DC bias point for transistor M1.

2. Use the results from Problem 1. Assuming that the transistor amplification is V_{S2}/V_{IN} = -3V/V. Assume the input frequency is operating within the circuits operating range. Assume that the amplification does not pull the transistors out of saturation. Create a rough sketch of the signal seen at V_{S2}. Mark all values for the y-axis and none on the x-axis. Will V_{S2} ever be 3V? Why or why not?

3.

Use: V_t=1V
   k_n'(W/L)=1mA/V^2
   λ=0

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_{S2}

(b) Solve for the DC voltages:

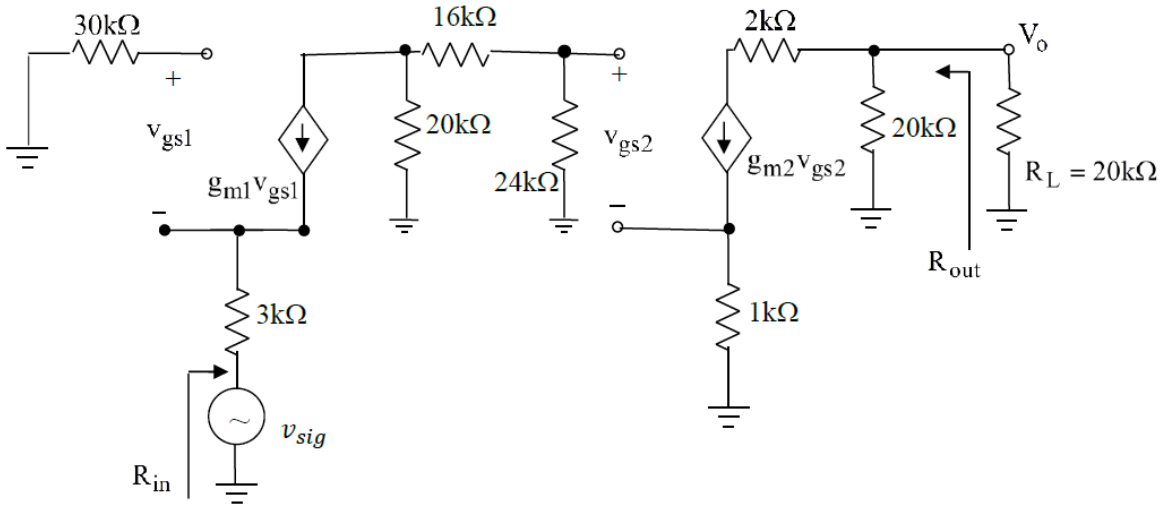
   a. V_{G2}
   b. V_{S2}
   c. V_{S1}

(c) Verify that transistor M2 is saturated.

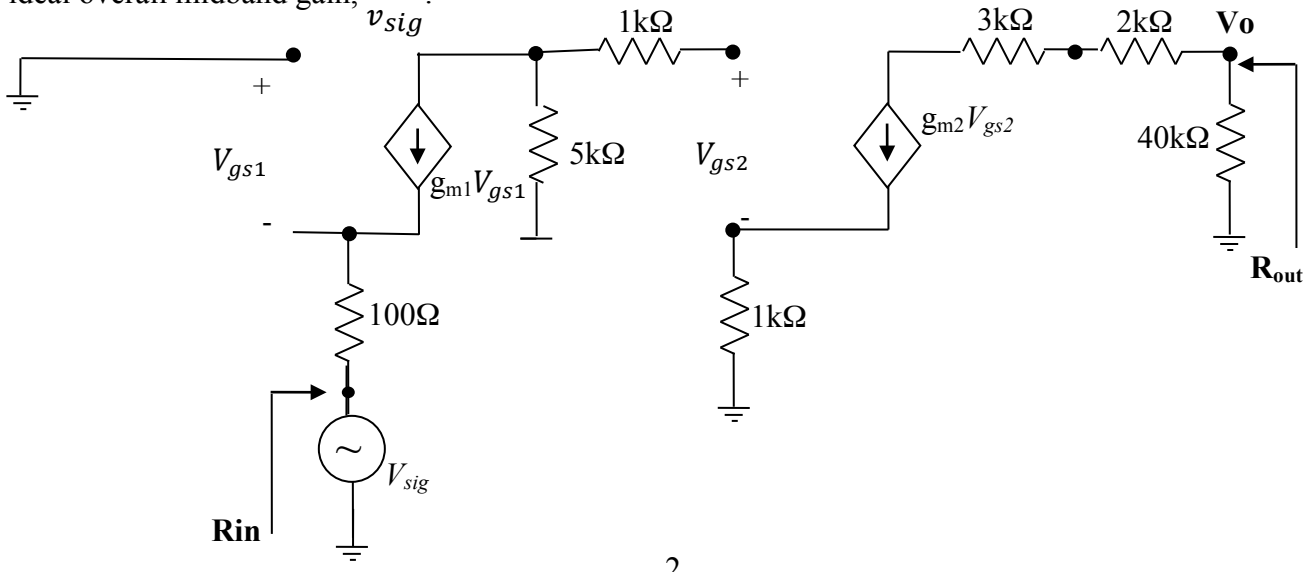
(d) State the DC bias point for transistor M1.

4. Use the results from Problem 3. Assuming that the transistor amplification is V_{S2}/V_{IN} = -30V/V. Assume the input frequency is operating within the circuits operating range. Assume that the amplification does not pull the transistors out of saturation. Will V_{S2} ever be 3V? Why or why not?

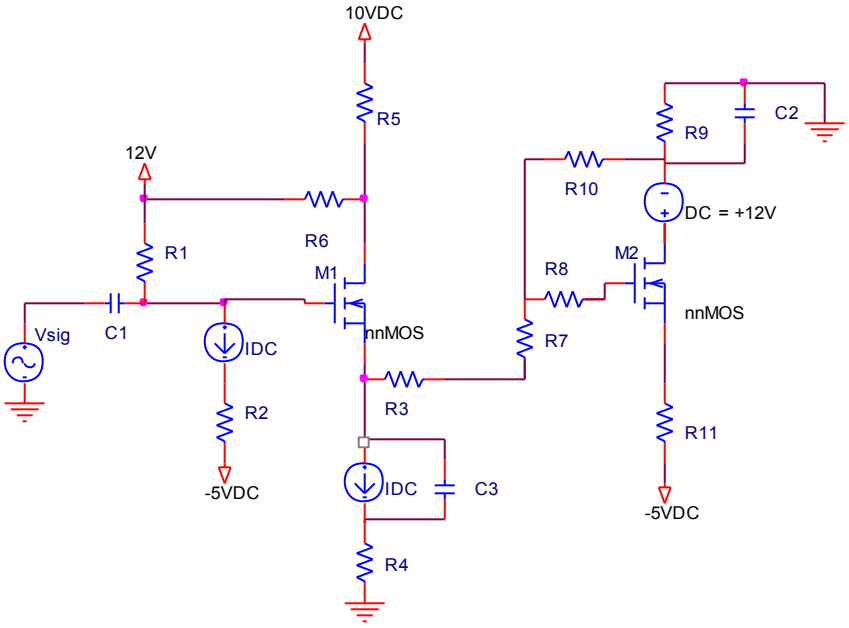
5. Use: V_t=1V, k_n'(W/L)=2mA/V^2, V_{sig} is an AC source, λ=0 and transistors are all saturated.
Transistor 1 has DC values: V_{GS}=1.5V, I_D=0.25mA
Transistor 2 has DC values: V_{GS}=13.5V, I_D=156.25mA
For the following hybrid-π equivalent circuit, find the following values:
(a) R_{in} (input resistance –ignore the input source, v_{sig})
(b) R_{out}(output resistance – ignore the load resistor, R_L)
(c) ideal overall midband gain, $\frac{V_o}{v_{sig}}$.



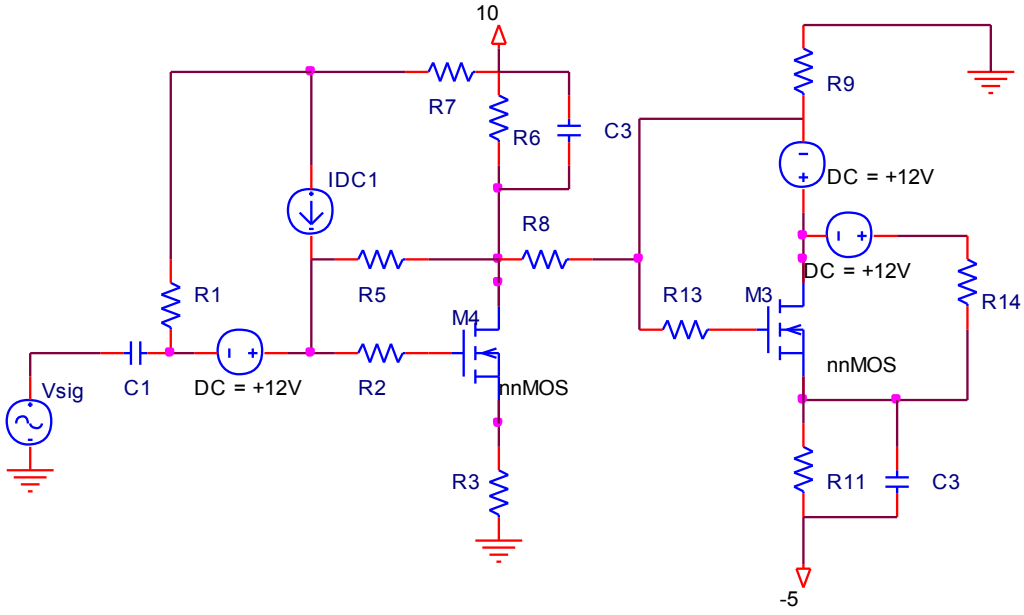
6. Use: V_t=1V, k_n'(W/L)=2mA/V^2, V_{sig} is an AC source, λ=0 transistors are all saturated.
Transistor 1 has DC values: V_{GS}=1.5V
Transistor 2 has DC values: I_D=156.25mA
For the following hybrid-π equivalent circuit, find the following values:
(a) R_{in} (input resistance –ignore the input source, v_{sig})
(b) R_{out}(output resistance – ignore the load resistor, R_L)
(c) ideal overall midband gain, $\frac{V_o}{v_{sig}}$.



7. For the circuit shown below, **draw** the AC small-signal equivalent circuit **with the capacitors** in it. 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).*Make sure to include drawing all R's unless they are floating*.



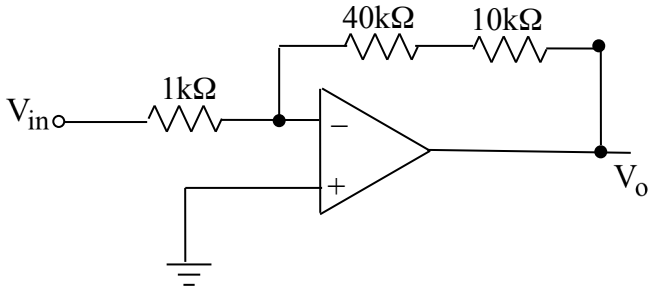
8. For the circuit shown below, **draw** the AC small-signal equivalent circuit **with the capacitors** in it. Make sure that everything is labeled in terms of the transistor number. (e.g. g_{m1}, v_{gs2}, r_{o1}, etc.). $\lambda \neq 0$ for all transistors.(i.e. draw the small-signal with r_o included).*Make sure to include drawing all R's unless they are floating*.



9. You are given the following characteristics for real amplifiers:

Symbol	Parameter	6484	6484M	6154	Units
V_{os}	Input Offset Voltage	2 2.7	3.0 3.7	5 7	mV max
SR	Slew Rate	1.0 0.7	0.9 0.54	24 15	V/μs min
GBW	Gain-Bandwidth Product	1.5	1.5	75	MHz
Av	Large Signal Gain	100	80	55	V/mV

The following circuit is powered at $\pm$9V:



a) (3 points) What value is the ideal gain?

b) (10 points) If a 6484 amplifier is used(first column), what is the bandwidth of the circuit considering both the Unity-gain bandwidth limitations and the slew rate effect(use the worse case scenario) for an input of V_{in}=0.1sin(ωt)?

c) (3 points) If a 6154 amplifier is used instead of that for (b), will the bandwidth be larger or smaller than that of (b)?

d) (5 points) If a 6154 amplifier is used, for V_{in}=0.1sin(ωt), what is the **maximum** and **minimum** values seen at the output considering only the input offset voltage? Hint: Use the worse case scenario.

e) (5 points) What is the best amplifier to achieve the following:

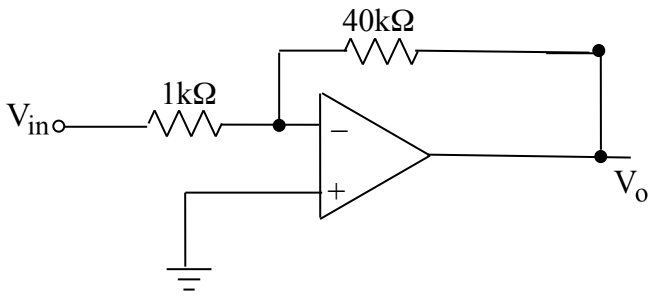
i) lowest error
ii) lowest dc offset at the output
iii) largest bandwidth possibility

f) (4 points) How should the circuit above be modified(do not remove any resistors) to minimize the effect of the input bias current? Draw the schematic of the modified circuit and state values of added component(s).

10.
You are given the following characteristics for real amplifiers:

Symbol	Parameter	6570	6380	6230	Units
V_{os}	Input Offset Voltage	2 3	3 4	5 7	mV max
SR	Slew Rate	1.0 0.5	1.0 0.1	24 15	V/μs min
GBW	Gain-Bandwidth Product	1	1.5	75	MHz
Av	Large Signal Gain	70	100	50	V/mV

The following circuit is powered at $\pm$10V:



a) (3 points) What value is the ideal gain?

b) (10 points) If a 6570 amplifier is used(first column), what is the bandwidth of the circuit considering both the Unity-gain bandwidth limitations and the slew rate effect(use the worse case scenario) for an input of V_{in}=0.1sin(ωt)?

c) (3 points) If a 6380 amplifier is used instead of that for (b), will the bandwidth be larger or smaller than that of (b)?

d) (5 points) If a 6230 amplifier is used, for V_{in}=0.1sin(ωt), what is the **maximum** and **minimum** values seen at the output considering only the input offset voltage? Hint: Use the worse case scenario.

e) (5 points) From the 3 amplifiers listed above, what is the best amplifier to achieve the following:

i) lowest error
ii) lowest dc offset at the output
iii) largest bandwidth possibility

f) (4 points) How should the circuit above be modified(do not remove any resistors) to minimize the effect of the input bias current? Draw the schematic of the modified circuit and state values of added component(s).