ECE 3200 Electronics II
Spring 2018
EXAM #3

NAME: ____

INSTRUCTIONS:

1. **THIS EXAM IS CLOSED BOOK AND CLOSED NOTES** other than one-side of a 3”x5” note card. Write your name on the unused side of the card. **Turn your card in with the exam.**
2. **YOU MAY USE ONE OF THESE CALCULATORS.**
   Circle the one, if any, that you are using:

   Casio fx-115/fx-991

   HP 33s/35s

   TI 30X/36X
3. **All other electronic devices must be stowed away**.
4. Work each problem in the provided space.
5. Show ALL work required to arrive at a solution for either full or partial credit.
6. READ the entire question before answering.
7. Have your student ID on your desktop for inspection by the instructor.
8. SIGN the honesty pledge at the bottom of the page. Exams without a signature will receive no credit.

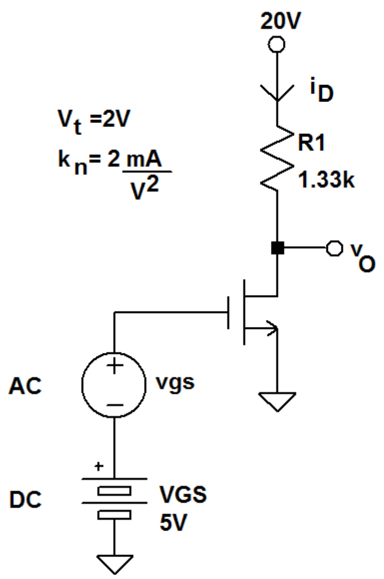
I have neither given nor received assistance from anyone in regards to completion of this exam.
I have followed the instructions as provided on this sheet.
I have verified that the exam has (7) pages.

SIGNATURE: ________________________________ DATE: ___________

Note: some problems might be adapted from the course text or other sources. Schematics prepared using LTspice® (linear.com).

Maximum exam score is 35/30 (problem 4 is worth (5) points extra credit).

1. Consider the following circuit.
   Ignore λ.
   a. (2 points) Find the Q point (I_D, V_{DS}).
   b. (2 points) Verify that the transistor is in the saturation region.
   c. (4 points) Draw the small-signal equivalent circuit diagram.
   d. (2 points) Use (c) to find the small signal voltage gain.



Adapted directly from: Sedra and Smith, Microelectronic Circuits, 3rd ed.

EXTRA WORK SPACE FOR PROBLEM 1

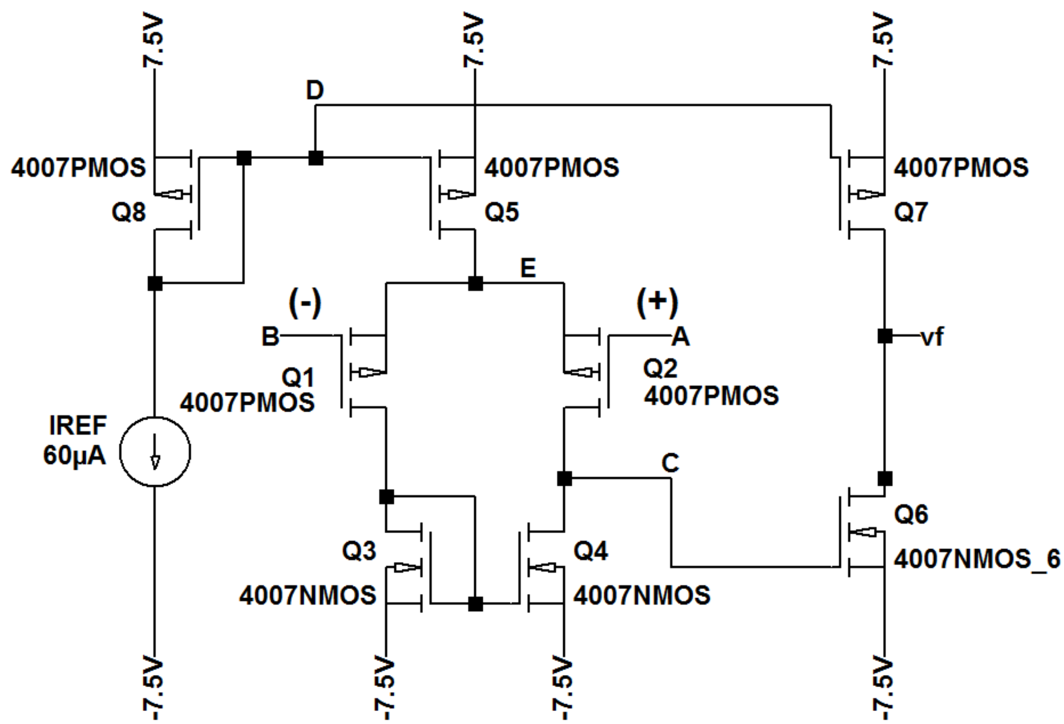
2. (10 points) Consider the following CMOS op-amp circuit. Find the small-signal voltage gain

$$v_f/v_{id} = \{g_{m1}(r_{02}||r_{o4})\}\{-g_{m6}(r_{06}||r_{o7})\}$$

where $v_{id} = (v_a - v_b)$.

Assume that the transistors are in the saturation region. Also:

- $k_n' = k_p' = 1$ mA/V^2 (does NOT include W/L)
- $\left(\frac{W}{L}\right)_8 = \left(\frac{W}{L}\right)_5 = \left(\frac{W}{L}\right)_7 = \left(\frac{W}{L}\right)_1 = \left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_3 = \left(\frac{W}{L}\right)_4 = 1$ and $\left(\frac{W}{L}\right)_6 = 2$.
- $V_{tn} = 1\text{V}$ and $V_{tp} = -1\text{V}$
- Ignore the channel-length modulation effect (λ=0) in any DC computations.
- $V_{An} = -V_{Ap} = 50\text{V}$



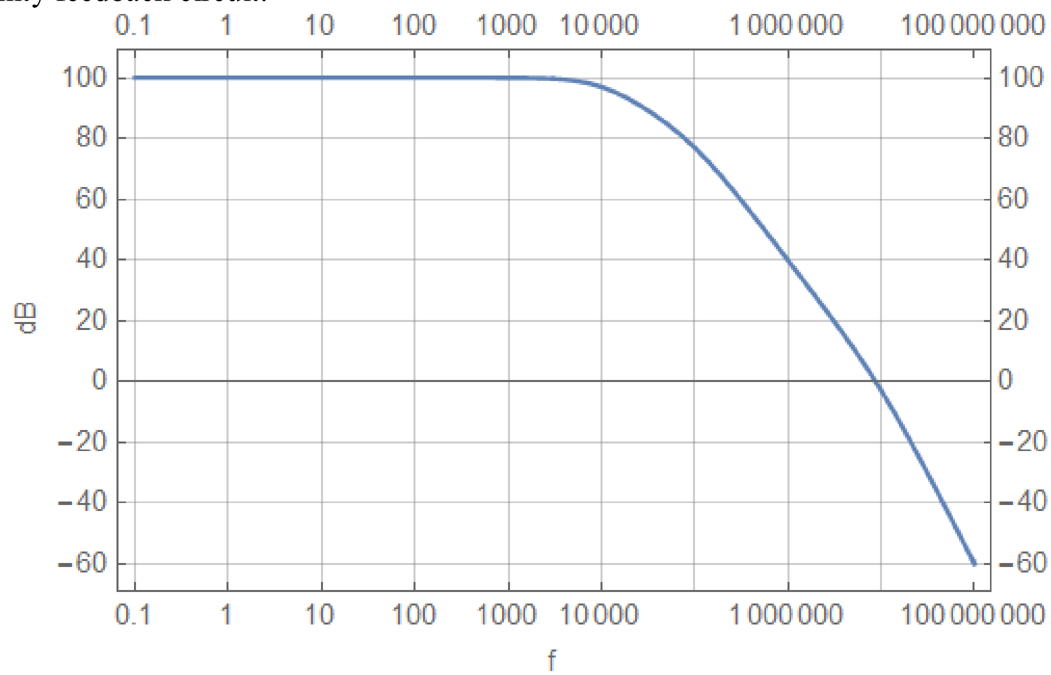
Adapted directly from Smith, Laboratory Explorations for Microelectronic Circuits, 4th ed.

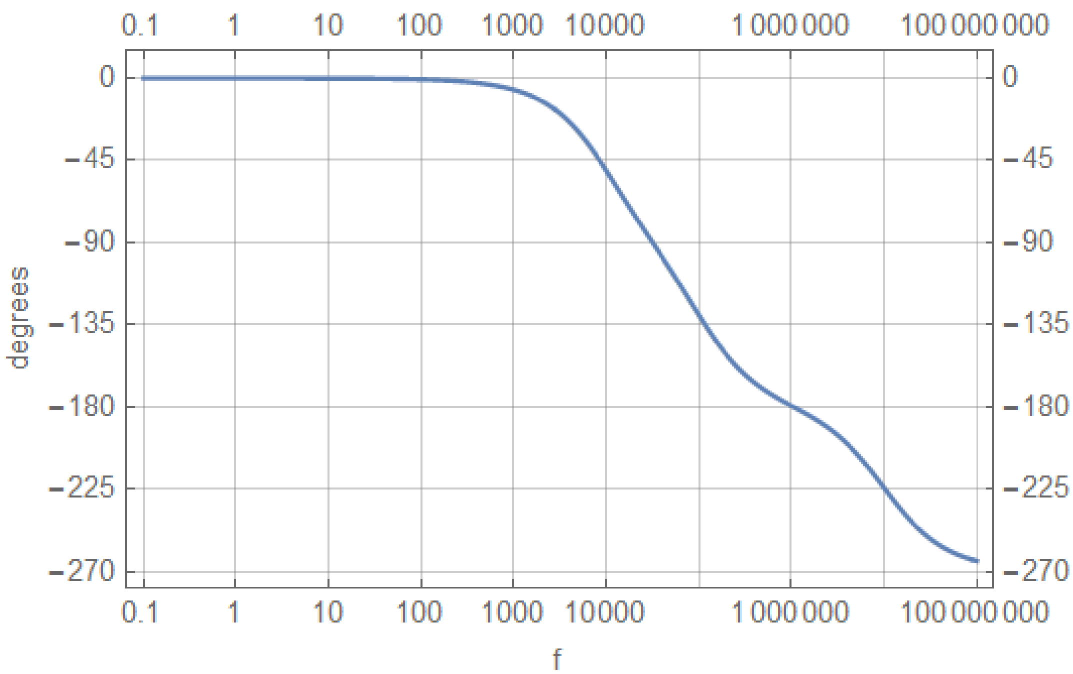
EXTRA WORK SPACE FOR PROBLEM 2

3. (10 points) An operational amplifier has the following open-loop gain and phase characteristics. Note that the poles are at 10kHz, 100kHz, and 10MHz.

   a. Find the minimum stable closed-loop gain.

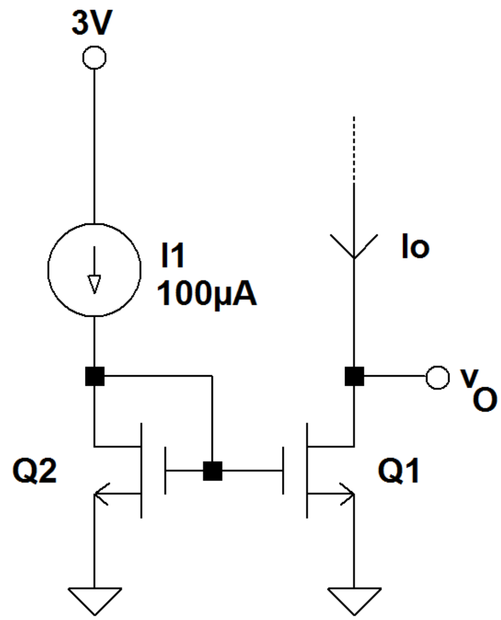
   b. Find a new frequency for the first pole so that the operational amplifier can be used in a unity feedback circuit.





4. (5 points, EXTRA CREDIT) Consider the following circuit. If Vo=2V, find Io.
Assume

- $\left(\frac{W}{L}\right)_2 = \left(\frac{W}{L}\right)_1 = 10$
- $V_{tn} = 0.7\text{V}$
- $k_n' = 200\ \mu\text{A/V}^2$ (does NOT include W/L)
- $V_{An} = 20\text{V}$



Problem based on Example 8.1 of Sedra and Smith, *Microelectronic Circuits*, 7th ed.