Exam is open-book, open-notes. Clearly mark results with box around. No credit for ambiguous solutions. Show derivations. Return this cover page. Good luck!

UID #: ____________________________

Name: ____________________________

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1. A source-degenerated PMOS differential amplifier is shown below. Assume
   \[ I_d = \frac{1}{2} k' \left( \frac{W}{L} \right) (V_{gS} - V_{th})^2 \]
   \[ k' = 40 \mu A/V^2 \]
   and \[ \left( \frac{W}{L} \right) = 5 \]
   for \( M_1 \) and \( M_2 \) in your calculation.

   You may ignore capacitance in your calculation for low frequencies. Answer the following questions.

   1) Assuming sine-wave input drive, what input amplitude would produce 1% IM3 at the output? [30]

   2) If two identical stages of the amplifier are cascaded, repeat the calculation in 1). Take the output from the second stage. [20]
2. [50] For the active cascode amplifier shown below, assume that the auxiliary amplifier is ideal with a gain of $A_a$. With the output $V_o$ attached to an AC ground, the effective transconductance $G_m$ of the amplifier is defined as

$$G_m = \frac{I_o}{V_i}$$

Answer the following questions using the return-ratio (RR) method. Assume that $g_{m1}$, $r_{oo}$, $g_{m2}$, and $r_{o2}$ are known. Ignore body effect.

1) For the feedback loop formed by $A_a$ and $M2$, what is the RR? [10]
2) Calculate $G_{m,\infty}$ when $RR = \infty$. [10]
3) Calculate $G_{m,0}$ when $RR = 0$. [10]
4) Use the asymptotic gain formula to derive an expression for the $G_m$ with finite $A_a$. [20]