Show derivations and mark results with box around them. Erase or cross-out erroneous attempts. Mark your name and SID at the top of the exam sheet.

1. [30 points] All component values in the amplifiers below are identical except for \( g_m^2 \), which is adjusted for 63 degrees phase margin with unity-gain feedback. Calculate the ratio of \( g_m^2 \) for amplifier A to \( g_m^2 \) for amplifier B as a function of \( C_{GS1}, C_{GS2}, C_1, C_2, C_L \). Treat all non-given parameters as ideal.
2. [15 points] The circuit below is “perfectly” symmetrical except for capacitor $C_x$ that was inadvertently added due to a layout error. Calculate $V_{od}$ for $V_{id}=0$ just before the end of phase $\Phi_2$. All transistors are NMOS, the amplifier is ideal, and $\Phi_1$ and $\Phi_2$ are 0V to 3V non-overlapping clocks.
3. [30 points] The amplifier below is placed in a negative unity-gain feedback loop (i.e. $v_i=-v_o$).
   
   a) Calculate the total output noise delivered to $C_2$ in V-rms as a function of $g_{m1}$, $g_{m3}$, $C_1$, $C_2$. Ignore the noise from $M3$, flicker noise and all capacitors except $C_1$ and $C_2$. All devices operate in the forward-active region and $g_{mro}>>1$.
   
   **Note:** $M3$ usually contributes more noise than $M1$ and $M2$ combined, but the math is a little too tedious to be appropriate for an exam: do only if you are done with all other problems.
   
   b) Calculate the ratio $g_{m1}/g_{m3}$ required for a 63-degree phase margin with unity-gain feedback.

![Circuit Diagram]
4. [25 points] All transistors in the circuit below operate in the forward active region, have nominally the same W/L, and are biased at $V_{dss} = 200$ mV (assume “square-law characteristics”). All devices are subject to the following random variations: 
$\sigma_{VTH_0} = 2$ mV, $\sigma_{\Delta(W/L)/(W/L)} = 0.2\%$, $\sigma_{\Delta(R/R)} = 0.5\%$, $\sigma_f = 0.01 V^{1/2}$.
Device Parameters: $\Phi_f = 0.3$ V, $\lambda \rightarrow \infty$.

a) Calculate the standard deviation of the input referred offset voltage, $\sigma_{V_{os}}$ at low frequency for $V_X = 0$ V and $V_X = 3$ V. Assume that the mismatch is small compared to the mean for all parameters.
b) Assuming $\sigma_{V_{os}} = 5$ mV (not the correct answer for part a), what is the fraction of amplifiers with an offset voltage less than 2 mV?