Problem 1 [25 points] (a) [12 points] In the circuit shown below, find $I_{out}$. Assume all transistors have the same size, and are in saturation. Assume $r_{o1} = r_{o2} = r_{o3} = \infty$. Assume the current source is ideal. Ignore short channel effect.

(b) [13 points] Find $I_{out}$ again for the circuit shown below.
**Problem 2 [25 points]** In the circuit shown below, find its small signal transfer function $H(s) = V_o/V_{in}$. Assume all transistors are in saturation and $r_o = \infty$. Ignore $C_{gd}$, $C_{sb}$, and $C_{db}$. Include $C_{gs}$ and body effect.
Problem 3 [25 points] In the circuit shown below, find the low frequency gains $v_{o1}/v_{in}$ and $v_{o2}/v_{in}$ in terms of $g_m$ and $r_o$. Assume all transistors are in saturation and the current sources are ideal. Ignore body effect.
**Problem 4 [25 points]** In the circuit shown below, find its small signal transfer function $H(s) = v_o/v_{in}$ in terms of $g_m$, $r_o$, and $C_{gs}$ of the transistors. Assume $r_o = \infty$. Assume all transistors are in saturation. Ignore $C_{gd}$, $C_{sb}$, $C_{db}$, and body effect. Assume the current source is ideal.

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*Write in Exam Book Only*