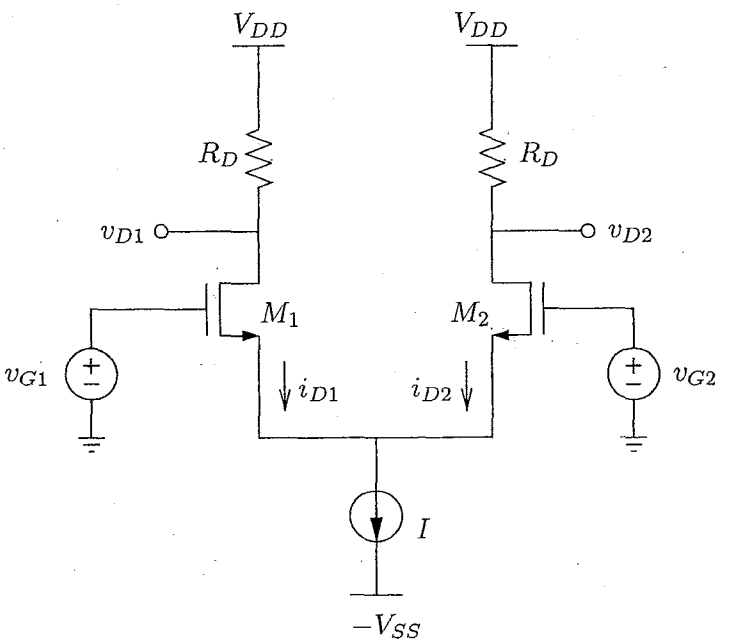
Problem 4



- This is a symmetrical differential amplifier, with M_1 and M_2 operating in saturation mode.
- When there is no differential input voltage ($v_{ID} = v_{GS1} - v_{GS2} = 0$) the tail current divides evenly between the two arms ($i_{D1} = i_{D2} = I/2$).
- The gate to source voltages must then also be equal: $V_{GS0} = v_{GS1} = v_{GS2}$.
- And $\frac{I}{2} = K_N(V_{GS0} - V_t)^2$ where $K_N = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}$.

(a) What is the minimum differential input voltage (v_{ID}) that can be applied to cause all current to flow through M_1? Please write expression in terms of $V_{GSO} - V_t$.

(b) What is the common mode rejection ratio? What is it for this circuit (assume differential input and differential output)?

Problem 5

Please describe the major sub-circuits of an op-amp, and the critical design considerations of each.