#1. (6 points) For the following circuit
   a) (3 points) Assume that the op-amp is ideal (linear, infinite gain, no input current). Find
      the transfer function \( \frac{v_o(s)}{v_i(s)} \).
   b) (3 points) Next assume that the op-amp gain, \( \frac{v_o}{v_d} \), rather than being infinite, has a first
      order pole and is given by
      \[ K(s) = \frac{K_0}{s + s_0} \]
      where \( K_0 \) and \( s_0 \) are real positive constants. In this case find \( \frac{v_o(s)}{v_i(s)} \) and give its zeros
      and poles.

#2 (7 points) The standard form for a degree two bandpass filter is
   \[ T(s, \zeta) = \frac{2\zeta}{s^2 + 2\zeta s + 1} \]
   where \( \zeta \) is the damping factor.
   a) (4 points) For sinusoidal excitations (that is, when \( s = j\omega \)) find the peak value of the magnitude
      \( |T(j\omega, \zeta)| \) for fixed \( \zeta \).
   b) (3 points) Obtain the sensitivity, \( S_{\zeta}^f \), of \( T(s, \zeta) \) to the damping factor \( \zeta \) and give its zeroes and
      poles. Here the sensitivity of a function \( f \) to a parameter \( x \) is defined as
      \[ S_{\zeta}^f = \frac{\partial f}{\partial x}\frac{x}{f(x)} \] (Note: the
      physical meaning of \( S_{\zeta}^f \) is the relative change of \( f \) with respect to the relative change of \( x \)).

#3) (7 points) For the circuit below assume that when \( V_o = V_i \) both transistors are in saturation with the
   NMOS described by
   \[ I_{on} = k_n(V_{GS} - V_{th})^2(1+\lambda V_{DS}) \]
   and matching PMOS (\( |V_{thp}| = V_{th}; \lambda_p = \lambda \)) except that \( k_p \neq k_n \).
   a) (3 points) Show that indeed the two transistors are in saturation when \( V_o = V_i \) (recall that
      saturation means that \( V_{GS} - V_{th} < V_{DS} \) for NMOS)
   b) (4 points) For \( V_{th} = 1 \text{Volt}, \lambda = 0.1 \) and \( VDD = 9 \text{Volts} \), find the ratio \( k_p/k_n \) such that \( V_i = V_o = 6 \text{Volts} \).
a) \( B_{0d}K_{V}V_{0} = V_{0} - V_{d} \) but \( V_{0} = 0 \) by op-amp virtual input connection

\[ V_{0} = V_{d} \] or \( \frac{V_{0}}{V_{d}} = 1 \)

b) \( G_{0} = \frac{V_{0}}{V_{d}} = \frac{1}{k_{0}} \quad \Rightarrow \quad \frac{V_{0}}{V_{d}} = \frac{1}{k_{0}} = \frac{K_{0}}{1 + K_{0}} \quad \Rightarrow \quad \frac{V_{0}}{V_{d}} = \frac{K_{0}}{1 + K_{0}} \]

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\[ \frac{V_{0}}{V_{d}} = \frac{K_{0}}{1 + K_{0}} \quad \Rightarrow \quad \text{Vout} @ V_{G} = V_{d} \quad (40 + K_{0}) \]

\[ \text{Vout} @ V_{G} = \infty \]

2. \( \text{MacLeish} \) \( w_{m} \) for \( \omega_{m} \)

\[ \left| T_{L}(\omega)\right| = \frac{(\omega_{m})^{2}}{(1 + (\omega_{m})^{2})} = \frac{G_{m} \omega_{m}}{1 + (\omega_{m})^{2}} \]

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\[ \left| \omega_{m}\right| = \frac{2.5}{\omega_{m}} \left( \frac{2.5}{\omega_{m}} + 1 + \frac{1}{\omega_{m}} \right) = 2.5 \]

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