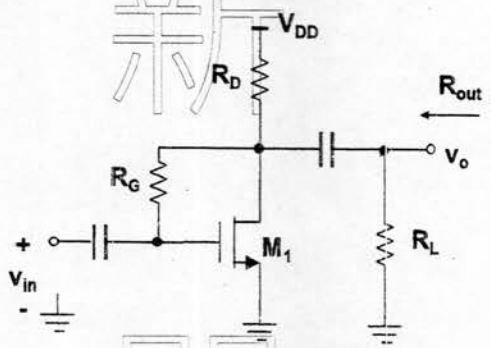
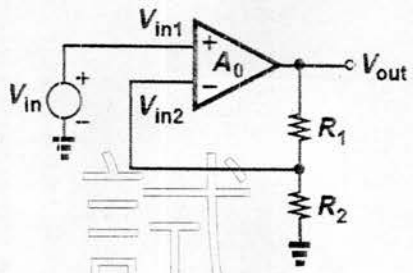
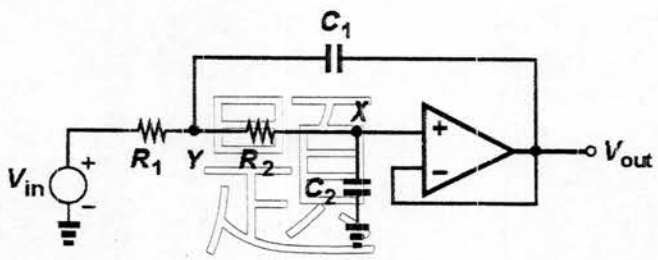
1. Assume the capacitors in the circuit shown below are sufficiently large so as to act as short circuits at the signal frequencies of interest. $V_{DD} = 1.5V$. $R_G = 1M\Omega$, $R_D = 4K\Omega$, $R_L = 4K\Omega$. M_1 has $V_{tn} = 0.5V$, $\mu_n C_{ox}(W/L)_1 = 0.4mA/V^2$, and $\lambda = 0.5V^{-1}$.
   (a) Find the DC operating point (I_{DS}, V_{DS}). **[5%]**
   (b) Draw the small-signal equivalent circuit. **[5%]**
   (c) Determine the voltage gain $A_v = v_o/v_{in}$. **[5%]**
   (d) Determine the output resistance R_{out}. **[5%]**



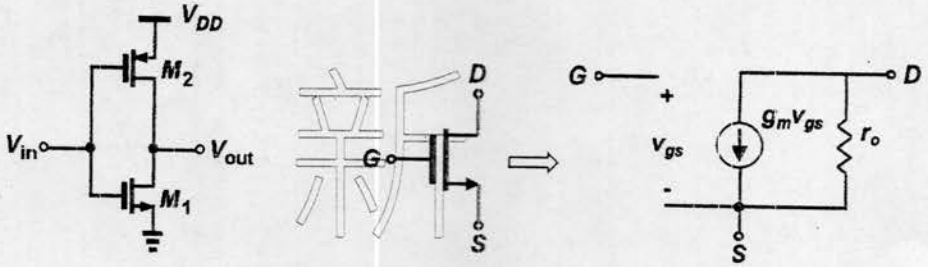
2. For the non-inverting amplifier shown below,
   (a) Derive its voltage gain, $A_v = V_{out}/V_{in}$, if $A_0 = \infty$. **[5%]**
   (b) Derive its voltage gain, $A_v = V_{out}/V_{in}$, if $A_0 \neq \infty$. **[5%]**
   (c) What is its gain error if $R_1/R_2 = 4$, and $A_0 = 1000$. **[5%]**



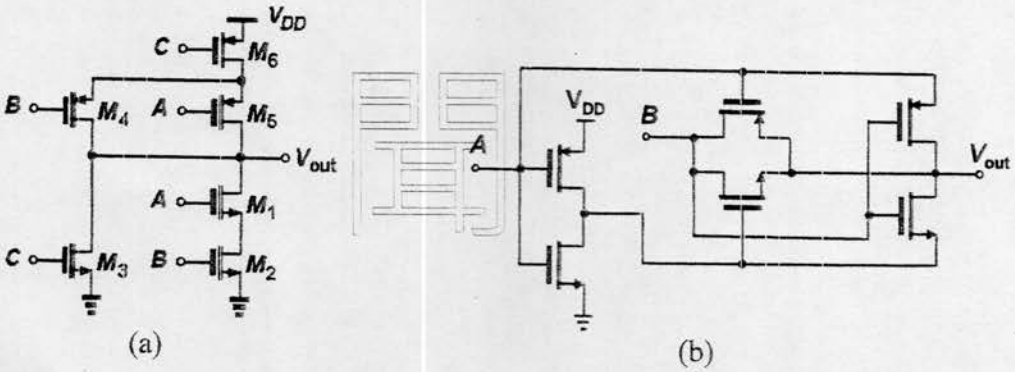
3. Assume the open-loop gain of the op-amp in the circuit below is infinite.
   (a) Derive the transfer function, $H(s) = V_{out}(s)/V_{in}(s)$. **[5%]**
   (b) Assume the second pole is much smaller than the first one. What are these poles? **[5%]**



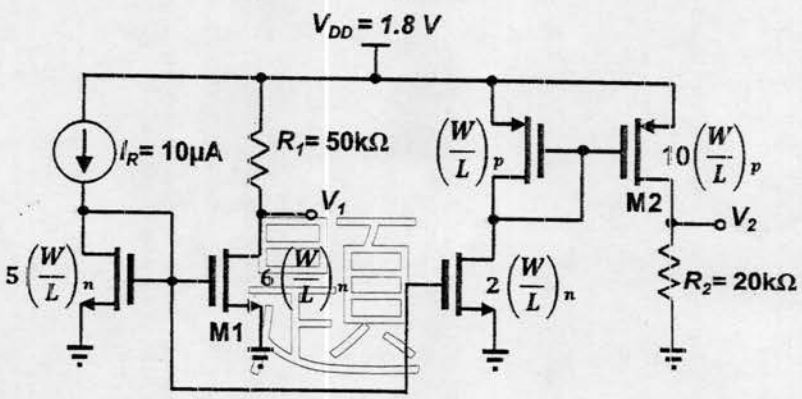
4. A CMOS inverter amplifier and small-signal equivalent circuit model of NMOS are shown below. Assume M_1 and M_2 have been properly biased at saturation region.
   (a) Draw the small-signal equivalent circuit for the inverter amplifier. **[5%]**
   (b) Derive the voltage gain, $A_v = V_{out}/V_{in}$. **[5%]**



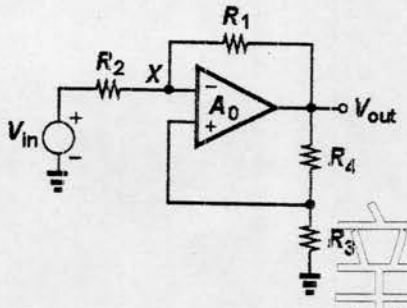
5. Assume all MOSs in the following two circuits are ideal switches. Determine their logic functions. **[10%]**



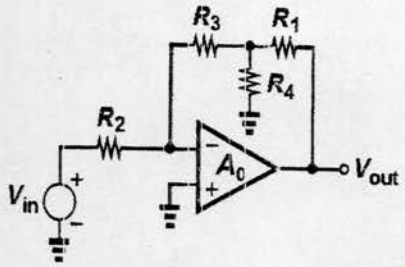
6. A current mirror application is shown below, where (W/L) is the ratio of width to length of MOS's. The drain-source voltage of MOS, $|V_{DS}|$, must be larger than 0.2V for good mirroring in the application.
   (a) Determine the voltage values of V_1 and V_2. **[5%]**
   (b) Find the maximum I_R that keeps both M1 and M2 saturation for good mirroring. **[5%]**



7. Determine the closed-loop gain of the following two circuits if $A_0 = \infty$. **[10%]**

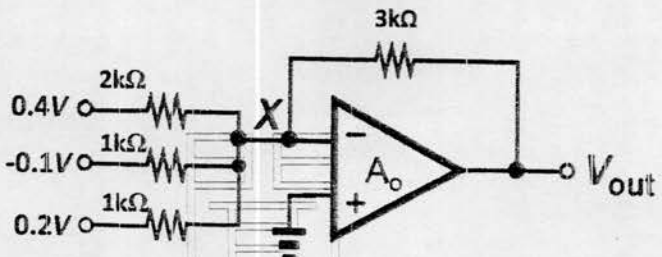


(a)



(b)

8. Find V_{out} for the circuit shown below if $A_0 = \infty$. **[5%]**



9. (a) Determine the input impedance, Z_{in}, for the circuit shown below. Assume $\lambda = 0$ **[5%]**
(b) At what condition $|Z_{in}|$ behaves as an inductance? **[5%]**