(if not specified, $v_d = v_1 - v_2$, $v_{cm} = (v_1 + v_2)/2$ for differential amplifiers. $\beta = 100$, $V_{BE}(on) = V_{EB}(on) = 0.7$ V) , $V_A = \infty$ and base current can be ignored for BJTs)

1. (10%) Consider the ideal series-shunt circuit shown in Figure 1. Let the amplifier with an open-loop gain $A_v = 5 \times 10^3$ V/V, $R_i = 30$ kΩ, $R_o = 2$ kΩ, $BW = 20$ kHz, and $\beta_v = 0.008$ V/V. Determine the ideal values of $A_{vf} = V_o/V_i$, R_{if}, R_{of}, and band-width for the close-loop amplifier.

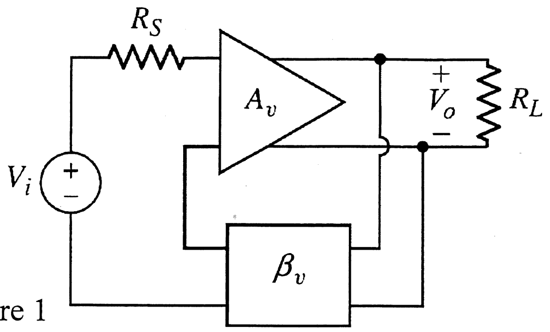

Figure 1

2. (10%) Figure 2 shows the ac equivalent circuit of the input stage of 741 op-amp, (a) Please use transistor parameters β_n, β_p, and small signal parameters such as $r_{\pi1}$, $r_{\pi3}$, g_m to represent the differential-mode input resistance R_{id}. (b) Use equivalent resistance shown in figure (such as r_{o4}, R_{act1}) and small signal parameters to represent differential voltage gain $A_v = v_{o1}/v_d$.

3. (10%) The transistor parameters in Figure 3 are $V_{TN} = 0.6$ V, $V_{TP} = -0.6$ V, $k_n' = 100$ μA/V², $k_p' = 60$ μA/V², and $\lambda_n = \lambda_p = 0.01$ V⁻¹. The width-to-length ratio are shown in the figure. Assume that M_1 and M_2 are biased in saturation region. (a) Determine the resistance looking into drain of M_2. (b) Determine the small signal voltage gain $A_v = v_o/v_i$.

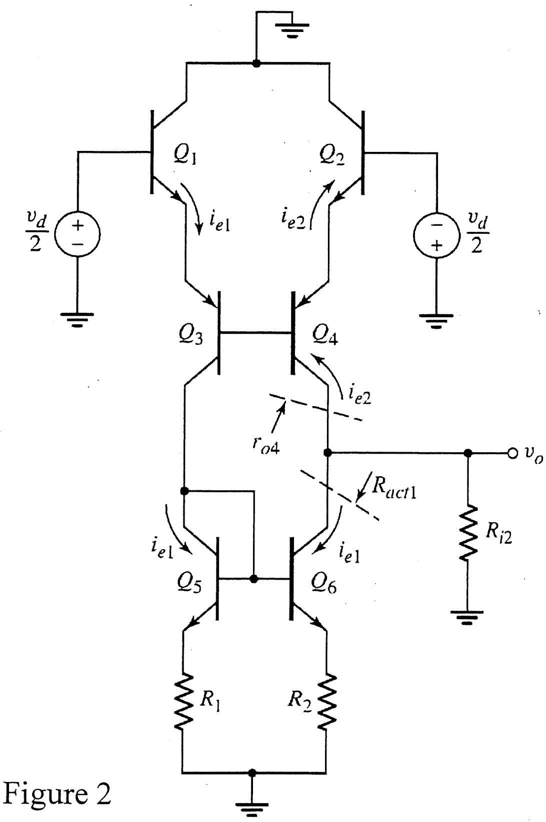

Figure 2

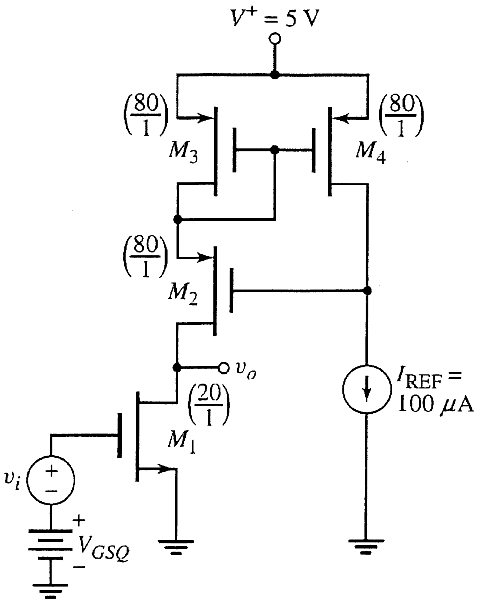

Figure 3

4. (9%) Let $R_{C1} = R_{C2} = 2\ \text{k}\Omega$, $R_{C3} = 1\ \text{k}\Omega$, $R_1 = 12\ \text{k}\Omega$. Determine I_{O1}, I_{O2}, and I_{O3} in Figure 4.

5. (25%) For the transistors in the circuit in Figure 5, the transistor parameters are $K_n = 0.2\ \text{mA/V}^2$, $V_{TN} = 2\ \text{V}$, and $\lambda = 0.02\ \text{V}^{-1}$. (a) Determine the value of bias current I_Q and the output resistance looking into current mirror (10%). (b) Determine $A_d = v_{o2}/v_d$ (5%). (c) Determine $A_{cm} = v_{o2}/v_{cm}$ (5%). (d) if the current mirror is replaced by a cascode current source with the same λ and the same I_Q, will A_d, A_{cm}, and CMRR become larger or smaller, or stay the same (5%)?

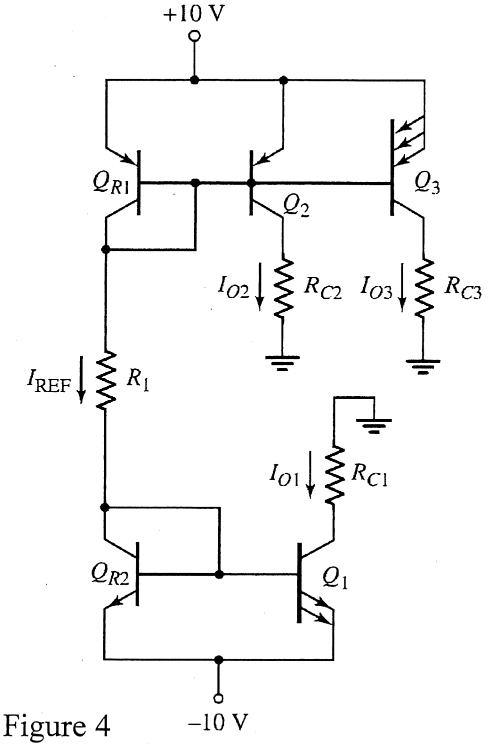

Figure 4

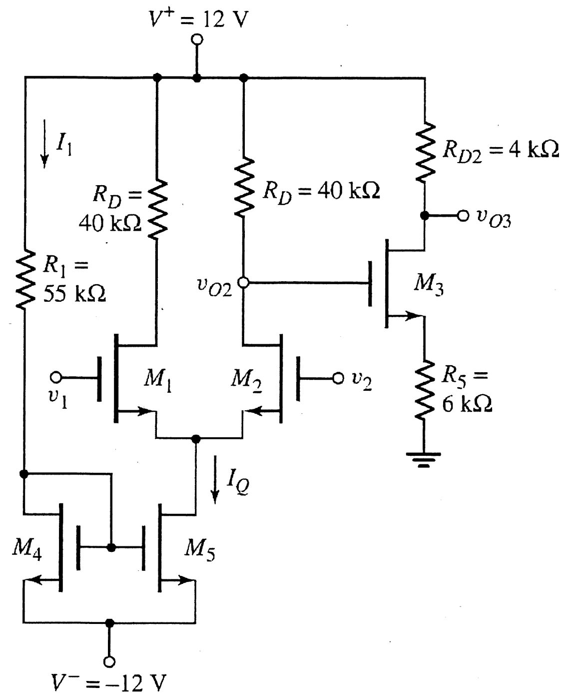

Figure 5

6. (10%) (P11.64)The differential amplifier with active load is shown in Figure 6. The circuit is biased with $I_Q = 0.2$ mA, and the transistor parameters are: $K_n = K_p = 100\ \mu\text{A/V}^2$, $\lambda_n = 0.01\ \text{V}^{-1}$, $\lambda_p = 0.015\ \text{V}^{-1}$, $V_{TN} = 1$ V, and $V_{TP} = -1$ V. (a) Find the open-circuit differential-mode voltage gain $A_d = v_o/v_d$. (b) What is the output resistance?

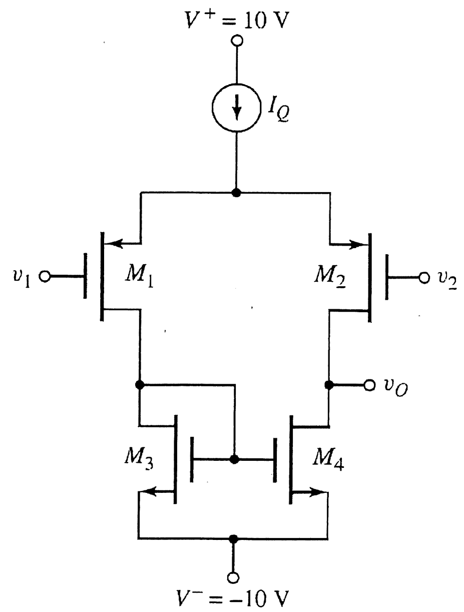

Figure 6

7. (26%) Consider the circuit in Figure 7. (a) Assume $V_{BE}(on) = 0.7$ V except for Q_8 and Q_9 and $V_A = \infty$, design the resistors such that $I_{C1} = I_{C2} = 0.1$ mA, $I_{R7} = 5$ mA, $I_1 = I_{R4} = I_{R6} = 0.6$ mA, $V_{CE1} = V_{CE2} = 4$ V, $V_{CE3} = 3$ V, and $V_O = 0$ V in pure common-mode (8%). (b) If $V_A = 100$ V for Q_8, determine the resistance looking into the collector of Q_8 (6%). (c) Determine the value of R_{i3} (6%). (d) Determine the small-signal voltage gain $A_2 = v_{o3}/v_{o2}$ (6%)

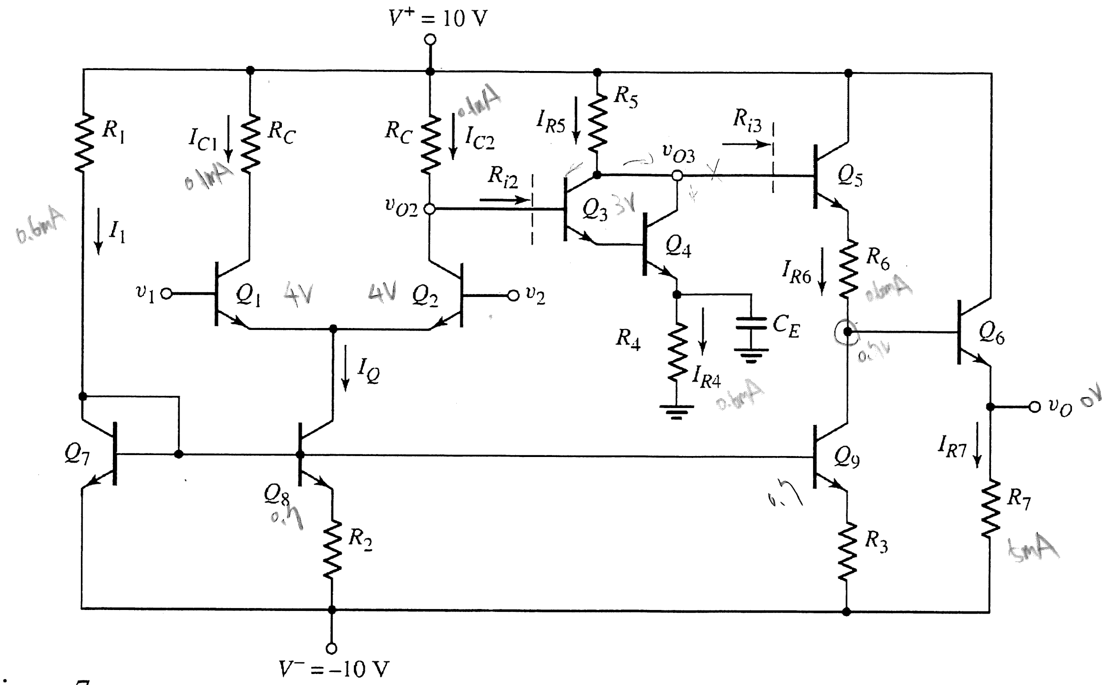

Figure 7

放暑假啦!!