1. (13%) Consider the circuit shown in Figure 1. Assume the transistor parameters are $V_{TN} = 0.8$ V, $K_n = 0.2$ mA/V^2, and $\lambda = 0$. Let $V_{DD} = 5$ V, $R_i = R_1 \parallel R_2 = 200$ kΩ and $R_{si} = 0$. (a) (8%) Design the circuit such that $I_{DQ} = 0.5$ mA and the Q-point is in the center of the saturation region. (b) (5%) Find the small-signal voltage gain.
2. (10%) The transistor in the circuit in Figure 2 has parameters $I_{DSS} = 8$ mA and $V_P = -4$ V. Determine V_G, I_{DQ}, V_{GSQ}, and V_{DSQ}.

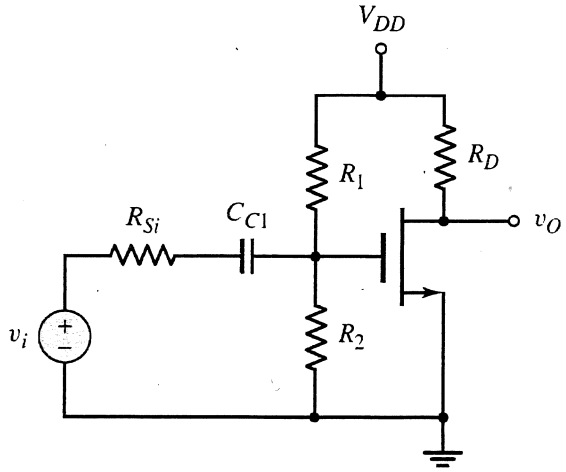

Figure 1

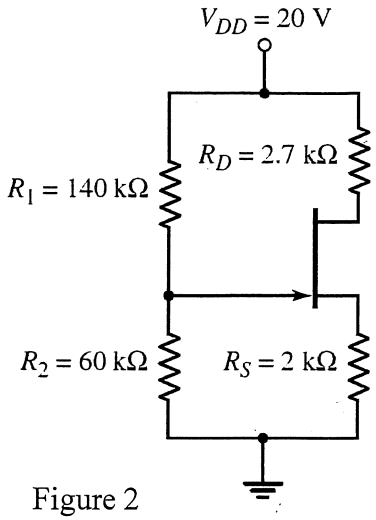

Figure 2

3. (15%) Consider the circuit shown in Figure 3, The transistor parameters are $V_{TP1} = -0.4$ V, $V_{TN2} = 0.4$ V, $(W/L)_1 = 20$, $(W/L)_2 = 80$, $k_p' = 40\ \mu$A/V^2, $k_n' = 100\ \mu$A/V^2, and $\lambda_1 = \lambda_2 = 0$. Let $R_1 + R_2 = 600$ kΩ. (a) (10%) Design the circuit such that $I_{DQ1} = 0.1$ mA, $I_{DQ2} = 0.3$ mA. The voltage across R_{S1} is to be 0.6 V and $V_{SDQ1} = 1$ V. (b) (5%) Determine the small-signal voltage gain $A_{v1} = v_{o1}/v_i$ for M_1.
4. (12%) Consider the constant-current source shown in Figure 4. Assume that the threshold voltage of each transistor is $V_{TN} = 1$ V. (a) Design the ratio of K_{n4}/K_{n3} such that $V_{GS3} = 2$ V. (b) Determine K_{n2} such that $I_Q = 0.1$ mA. (c) Find K_{n3} such that $I_{REF} = 0.2$ mA

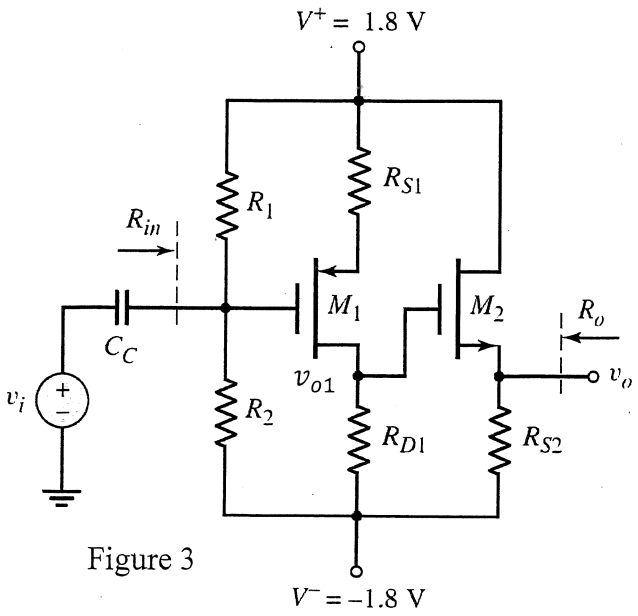

Figure 3

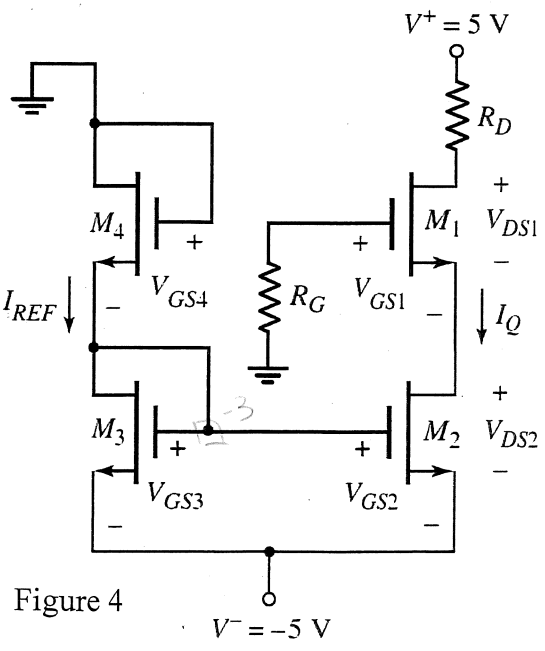

Figure 4

5. (15%) Consider the circuit shown in Figure 5 with circuit parameters: $V^+ = 5$ V, $V^- = -5$ V, $R_S = 4$ kΩ, $R_D = 2$ kΩ, $R_L = 4$ kΩ, and $R_G = 50$ kΩ. The transistor parameters are: $V_{TP} = -0.8$ V, $K_p = 1$ mA/V^2, and $\lambda = 0$. (a) Draw the small-signal equivalent circuit. (b) Determine the small-signal voltage gain $A_v = v_o/v_i$. (c) Find the input resistance R_i.

6. (15%) In the source-follower circuit shown in Figure 6, the transistor parameters are $V_{TN} = -2$ V, $K_n = 5$ mA/V^2, and $\lambda = 0.01$ V^{-1}. (a) Design the circuit such that $I_{DQ} = 5$ mA. (b) Find the small-signal voltage gain $A_v = v_o/v_i$. (c) Find the output resistance R_o.

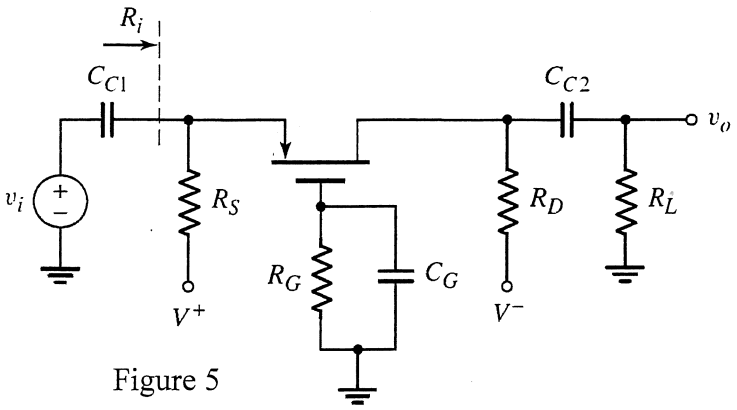

Figure 5

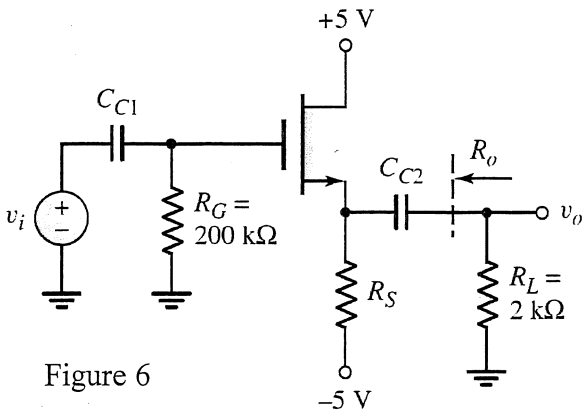

Figure 6

7. (20%) For the NMOS amplifier with depletion load in Figure 7, the transistor parameters are $V_{TND} = 0.6$ V, $V_{TNL} = -0.8$ V, $K_{nD} = 1.2$ mA/V^2, $K_{nL} = 0.2$ mA/V^2, and $\lambda_D = \lambda_L = 0$. Let $V_{DD} = 5$ V. (a) Determine the transfer voltage (V_{GSD} and V_O) at the transition points A and B. (b) Find V_{GSDQ} and V_{DSDQ} such that the Q-point is in the middle of the saturation region. (c) Determine I_{DQ}. (d) Following (c) and assume that $\lambda_D = \lambda_L = 0.01$ V^{-1}, find the small-signal voltage gain.

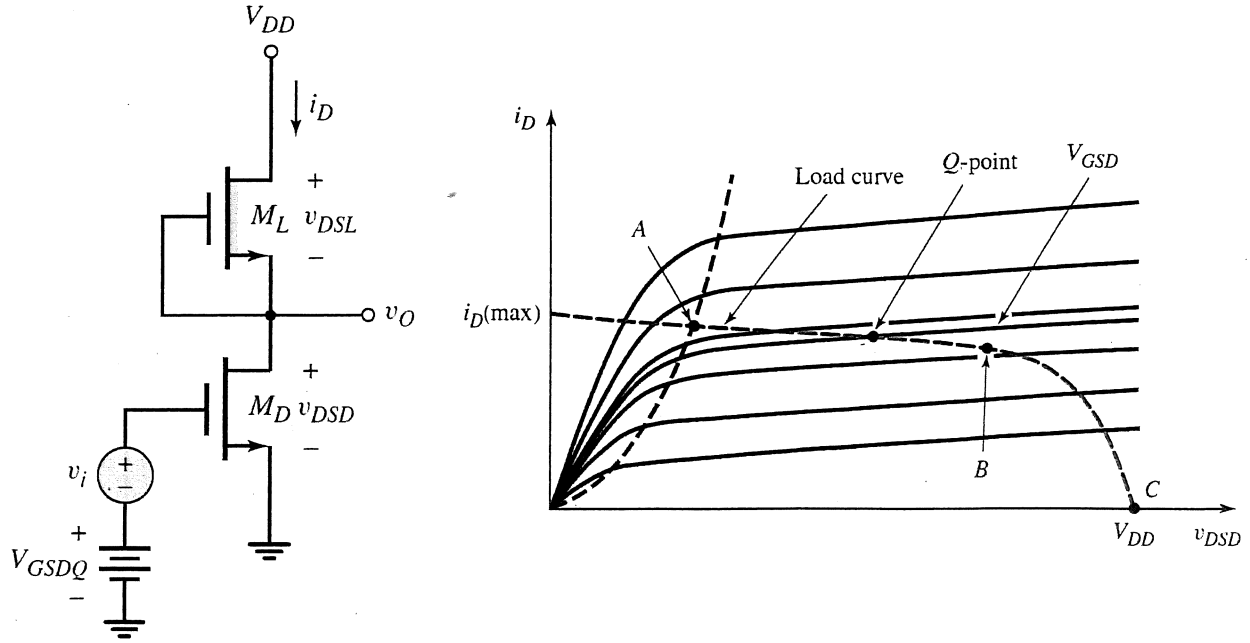

Figure 7

祝大家有個愉快的寒假和春節！！