1. Find the concentrations of electrons and holes in a sample of silicon that has a concentration of donor atoms equal to 5×10^{15} cm^{-3}. Is the semiconductor n-type or p-type? (10%)

2. In the voltage regulator circuit in Figure 1, let $V_i = 6.3$ V, $R_i = 12\Omega$ and $Vz = 4.8$ V. The Zener diode current is to be limited to the range $5 \le I_Z \le 100$ mA. Determine the range of possible load currents and load resistances. (10%)

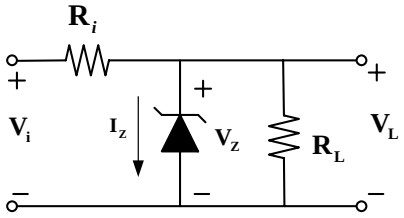

Figure 1

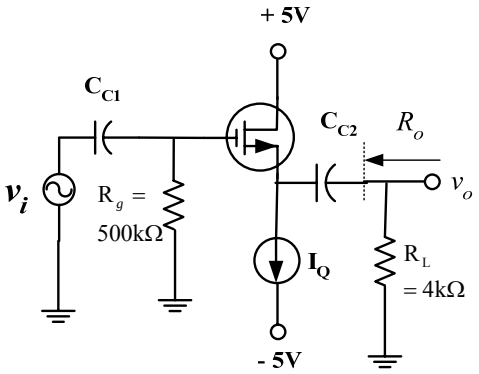

Figure 2

3. Consider the source-follower circuit in Figure 2, with transistor parameters $V_{TN} = 1.2$ V, $K_n = 1$ mA/V^2 and $\lambda = 0.01$ V^{-1}. If $I_Q = 1$ mA, find the small-signal transistor parameters and determine the small-signal voltage gain $A_v = v_o / v_i$. (15%)

4. The dc load line and *Q*-point of the circuit in Figure 3(A) are shown in Figure 3(B). Assume $V_{EB\,(on)} = 0.7$V. (a) Find the transistor parameters β and α. (b)Find R_C. (15%)

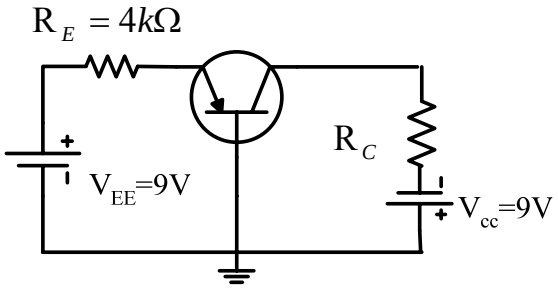

Figure 3 (A)

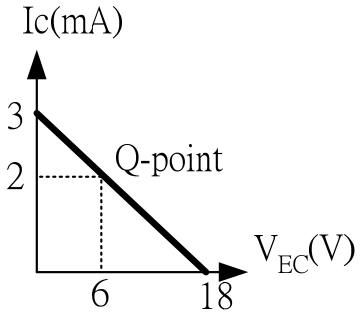

Figure 3 (B)

5. For the circuit in Figure 4, the transistor parameters are: $\beta = 100$, $V_{BE}(on) = 0.7\,V$, and $V_A = 100\,V$. Determine the lower 3dB corner frequency. (15%)

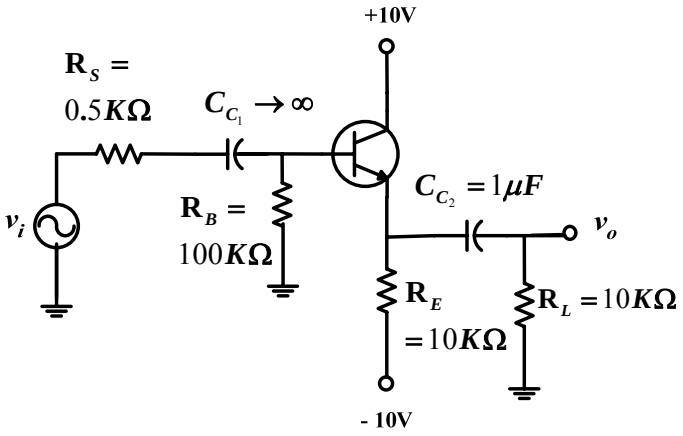

Figure 4

6. Consider a four-pole feedback system with a loop gain given by

$$T(f) = \frac{(10^3)\beta}{(1+j\frac{f}{10^3})(1+j\frac{f}{10^4})(1+j\frac{f}{10^5})(1+j\frac{f}{10^6})}$$

Determine the value of β that produces a phase margin of 40 degrees. (15%)

7. Consider the circuit in Figure 5. (a) Derive the expression for v_O in terms of v_I and the resistors. (b) Derive the expression for i_3 in terms of v_I and the resistors. (10%)

8. Consider the diff-amp in Figure 6. The transistor parameters are: $k_{n1} = k_{n2} = 80\,\mu A/V^2$, $\lambda_1 = \lambda_2 = 0$, and $V_{TN1} = V_{TN2} = 1V$. Using the small-signal equivalent circuit, determine the differential-mode voltage gain $A_d = v_{o2}/v_d$. (10%)

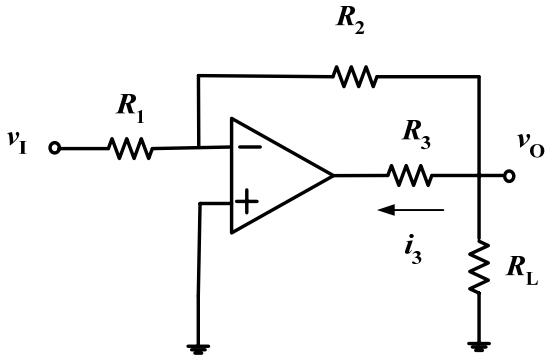

Figure 5

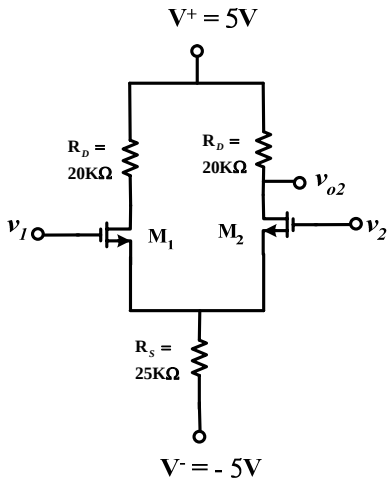

Figure 6