1. A silicon sample has the characteristics shown as follows.
   (1) Calculate the resistivity. (6%)
   (2) Under thermal equilibrium, calculate the minority carrier concentration. (6%)
   (3) Calculate the minority carrier diffusion length. (8%)

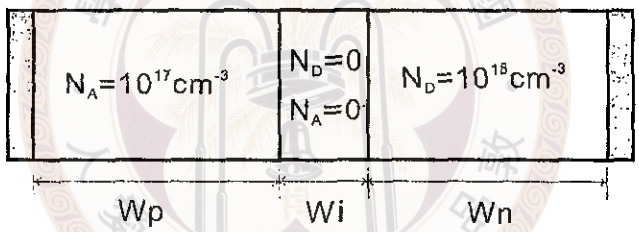
* $N_d = 4\times10^{16}\,\text{cm}^{-3}$; $\mu_n = 1.0\times10^{3}\,\text{cm}^2/\text{V-s}$; $\mu_p = 350\,\text{cm}^2/\text{V-s}$; $\tau_p = 2\times10^{-8}\,\text{s}$; $q = 1.9\times10^{-16}$ Coulombs;

$kT/q = 25\,\text{mV}$

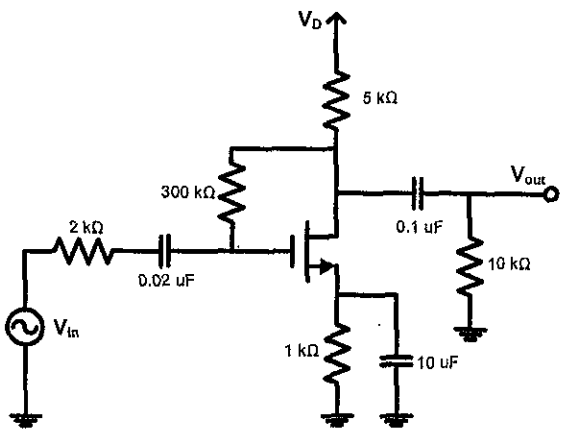
2. A silicon p-i-n diode has the characteristics illustrated as follows.
   (1) Sketch the space charge densities and electric field regarding x-axis. (10%)
   (2) Calculate the applied bias at the onset of reverse breakdown. (10%)
   (3) Calculate this reverse breakdown voltage for the case of a device without the intrinsic region (p-n diode). (10%)

   *Break down electric field $E_{BR} = 3\times10^{5}\,\text{V/cm}$; $\varepsilon_{Si} = 1.04\times10^{-12}\,\text{F/cm}$; $q = 1.9\times10^{-16}$ Coulombs;

   $kT/q = 25\,\text{mV}$; Wn = Wp = 10 μm; Wi = 0.1μm



3. Assume C_{gs} = 100 pF, C_{gd} = 2 pF, g_m = 5 mA/V, please find
   (a) Mid-band voltage gain A_M (9%)
   (b) Lower 3-dB frequency f_L of the amplifier (8%)
   (c) Upper 3-dB frequency f_H of the amplifier (8%)



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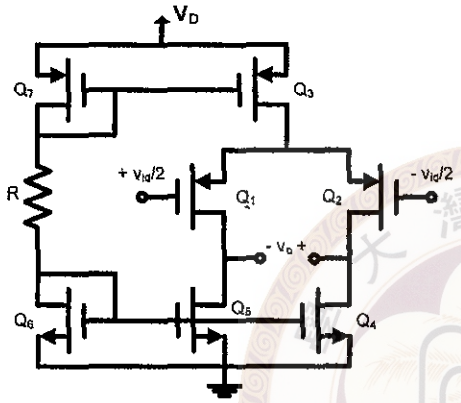
4. Assume that $V_D = 5V$, $R = 16k\Omega$, $\mu_n C_{ox} = 2\mu_p C_{ox} = 100\ \mu A/V^2$, $V_{tn} = |V_{tp}| = 0.7V$, $L = 1\mu m$, $W_1 = W_2 = 10\mu m$, $W_3 = 40\mu m$, $W_4 = W_5 = 10\mu m$, $W_6 = 2\mu m$, $W_7 = 4\mu m$. $V_{An} = |V_{Ap}| = 20V$. If the output is taken differentially, please find:
   (a) The current flowing through R (7%).
   (b) Differential gain (7%).
   (c) CMRR (6%).
   (d) Output resistance (5%).



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