University of California
College of Engineering
Department of Electrical Engineering and Computer Sciences

	Problem Set 5	**EE40**
Octavian Florescu	**Due Tuesday August 1st**	**Summer 2006**

Reading:

Chap 10-10.4 of Hambley.
Chap 2, 3.3-3.6 of Sodini and Howe.

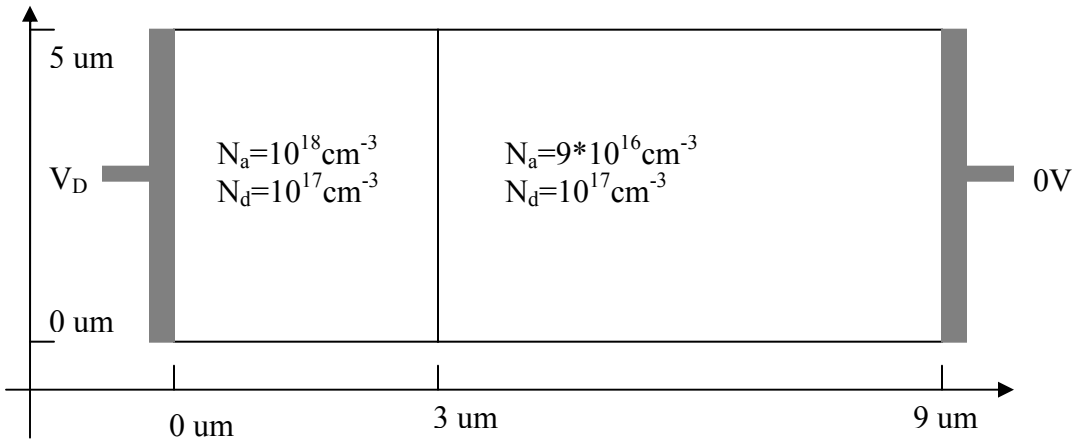
Problems:

Chap 10: 10.11, 10.13, 10.16, 10.21, 10.33, 10.34, 10.35
Chap 2: E2.4, E2.10, E2.11, P2.2, P2.5, P2.7, 2.10

Additional Problems:

Problem 1

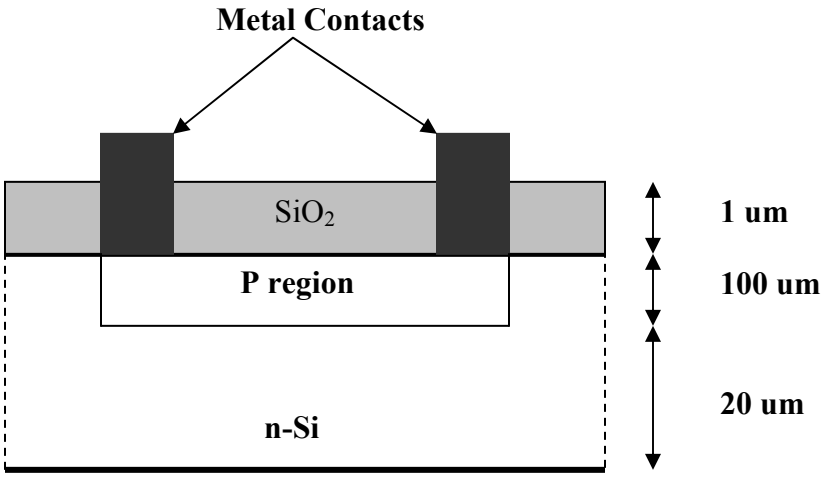
a. Explain in your own words how forward biasing a diode generates a current.
b. Explain in your own words how a reverse biasing a diode generates a current.
c. Find the majority and minority carriers in this device.
d. Draw the charge density, the electric field and the built-in potential of this device.
e. Find the junction capacitance if the thickness of this diode is 1um.



Problem 2

Consider the P region resistor below. The *n* substrate concentration is $10^{17}\,cm^{-3}$. A *P*-region is implanted on top of the n background, with an acceptor concentration of $1.1\times10^{17}\,cm^{-3}$. Assume $n_i = 10^{10}\,cm^{-3}$.

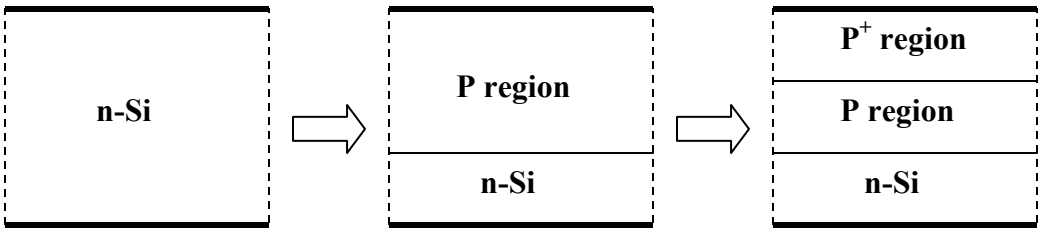
a. Find the majority carrier concentration for the *n* and *p* regions.
b. Find the sheet resistance between the metal contacts. Use the mobility plot in your notes.
c. Design a 1 $K\Omega$ resistor using the above manufacturing process. Show a top view of your resistor, and specify how many squares of the previous sheet resistance are required for your resistor.
d. For what values of voltages on the metallic contacts would this device stop working like a P region resistor? Assume the n-Si is biased to 2V.



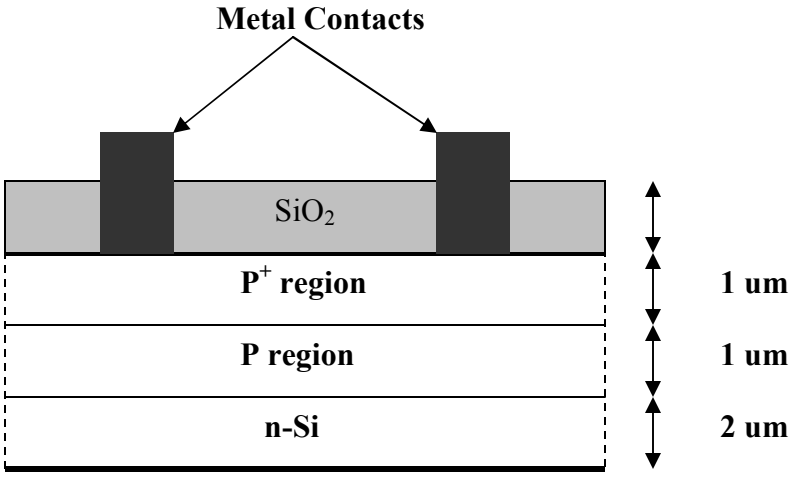
Problem 3

Consider the n-type silicon substrate below. The *n* background concentration is $10^{17}\,cm^{-3}$. A *P* region is implanted on top of the n background, with an acceptor concentration of $1.1\times10^{17}\,cm^{-3}$. A P^+ region is implanted on top of the *P* region with acceptors with the concentration of$10^{18}\,cm^{-3}$. Assume $n_i = 10^{10}\,cm^{-3}$.

a. Find the majority carrier concentration for the *n*, *p* and *p*+ regions.
b. Find the sheet resistance for the P^+ region.
c. Find the sheet resistance for the *P* region.
d. What is the total sheet resistance?



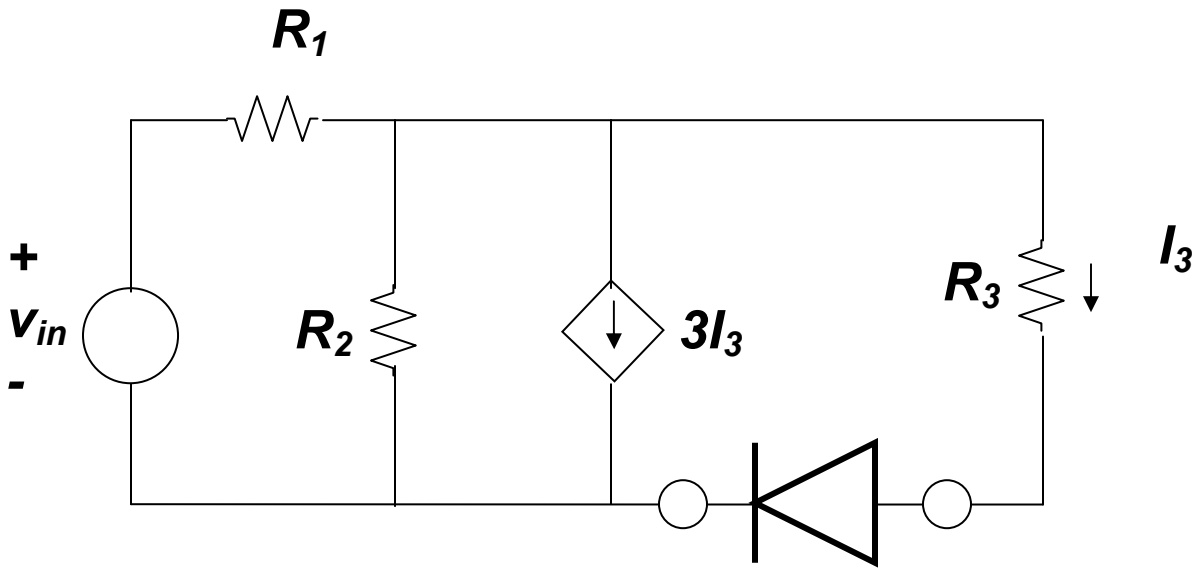
Step 1 **Step 2** **Step 3**



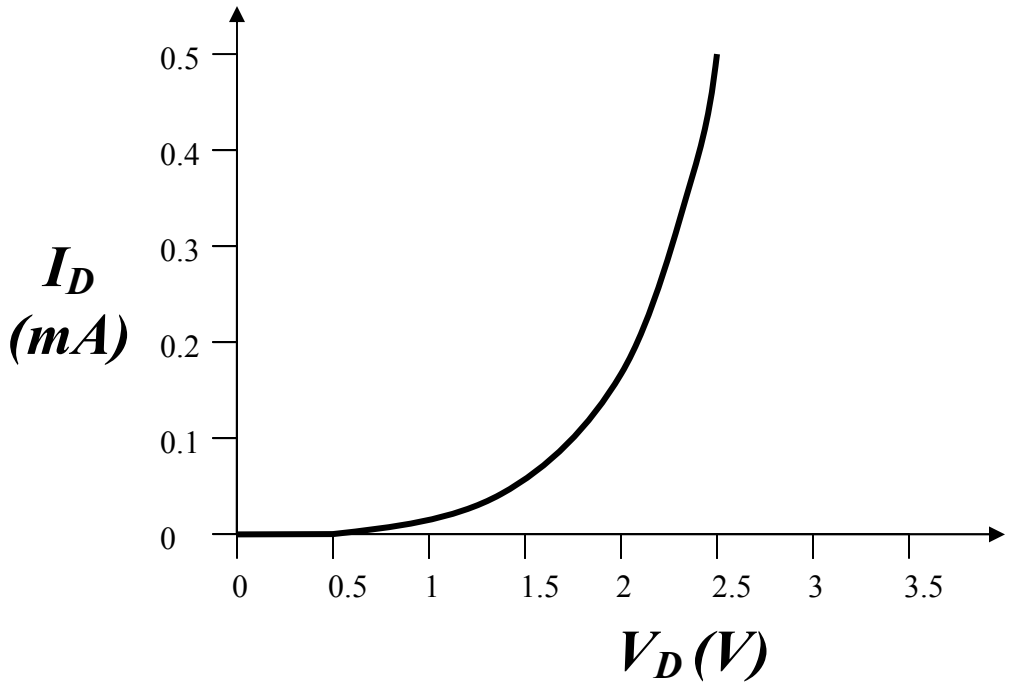
Final Step

Problem 4

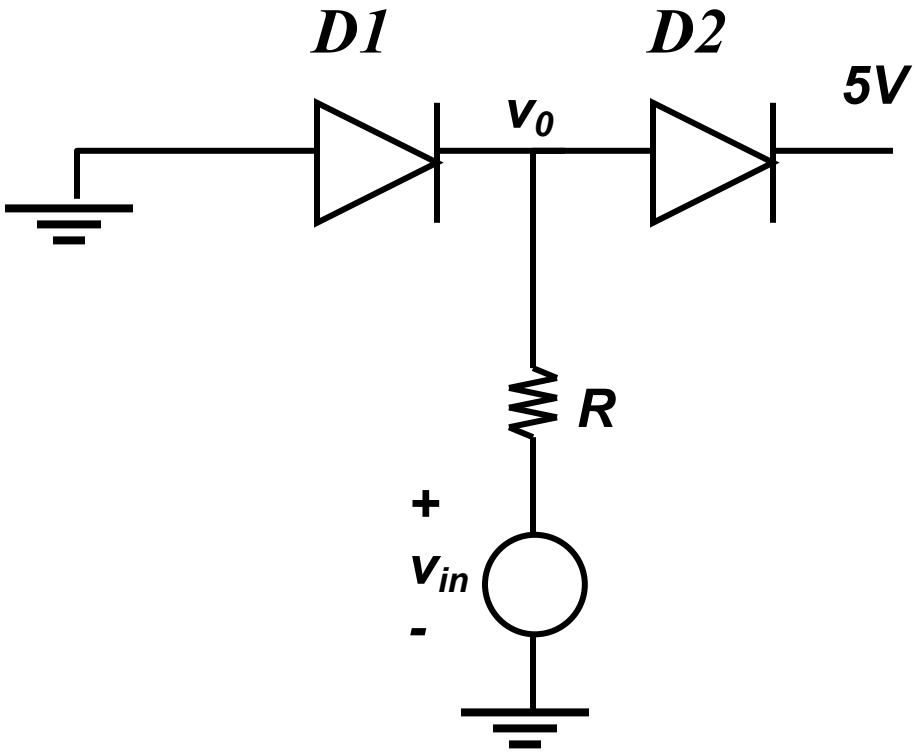
$R_1 = 2K\Omega, R_2 = 2K\Omega$, $R_3 = 4K\Omega$, and $Vin = 4V$



a) Draw the Thevenin equivalent circuit that the diode sees (i.e. the Thevenin equivalent for the two terminals of the diode).
b) Specify the Thevenin voltage and Thevenin Resistance.
c) Given the I-V characteristic shown below, find the Q points V_{diode} and I_{diode}.



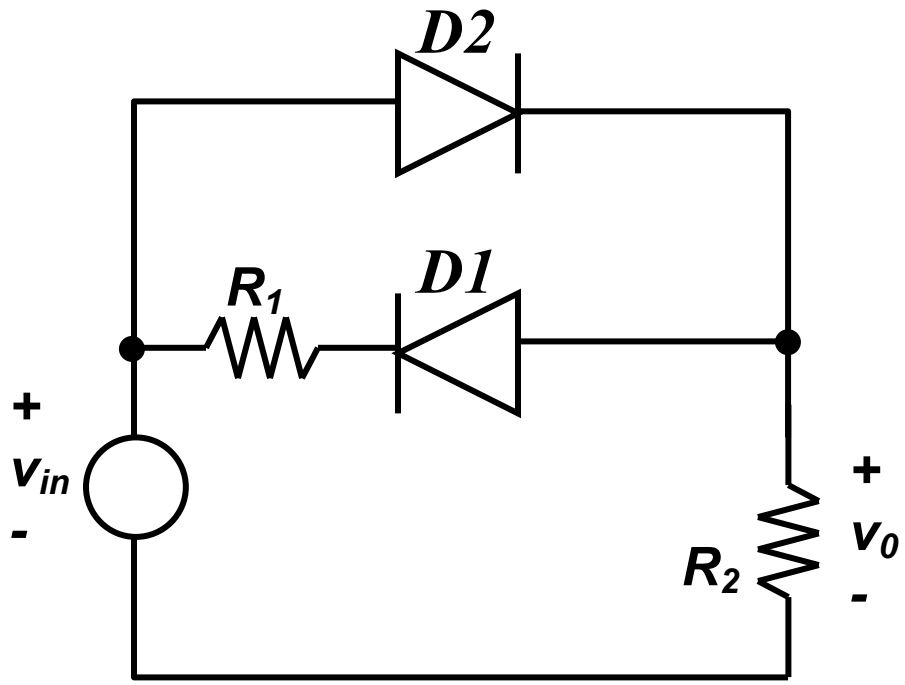
Problem 5



a. D1 and D2 have built-in potential voltages of 0.7 Volts. Use the Ideal model for D1 and D2 to plot V_o vs. V_{in}. *Hint: Try some sample voltages.*

Problem 6

Diodes D_1 and D_2 are p-n junctions with $N_A = 10^{18} cm^{-3}$ and $N_D = 1.5 \times 10^{17} cm^{-3}$ at room temperature. Assume n_i(T) = 10^{10} cm^{-3}



a. What is the built in potential of the diodes?
b. If $R_1 = 5K\Omega$ and $R2 = 10K\Omega$, plot V_o verses V_{in}. Use the large signal model for the diodes.