Homework Assignment # 2, Due February 2, 2001

All circuits in the following problems are fabricated in a N-well CMOS process
- oxide mask (dark field)
- polysilicon mask (clear field)
- contact mask (dark field)
- metal mask (clear field)
- N-well mask (dark field)

2.1 CMOS process flow. Consider the layout of a CMOS inverter. Use the 6 step process flow in Chapter 2 and add one additional mask (N-well) and two additional steps (N-well implant prior to step 1 and P-type source/drain implant prior to step 5.

![CMOS Inverter Layout](image)

a) Draw the cross section at cut-line A-A immediately after polysilicon etching
b) Draw the cross section at cut-line A-A immediately after contact opening
Specify substrate type, doping types in source/drain areas and each layer in your schematic.

2.2 CMOS Circuit. Consider the layout of a CMOS circuit
2.3 IC resistors. Consider the layout of an IC resistor. Assume sheet resistances of N+ doping, polysilicon and metal are $100\,\Omega$/square, $10\,\Omega$/square and $0.01\,\Omega$/square, respectively.

a) Sketch the cross section of the resistor at cut-line A-A
b) Calculate the total resistance $R_{BC}$ (Contact and corner resistances should be considered in your calculation. Assume that the contact regions each contribute 0.65 squares)

2.4 IC resistors.

a) If the N+ doping in problem 2.3 is 0.5um deep and the distribution of dopant is uniform, find the doping concentration. (Assume the grid show on the drawing have 0.5um openings)

b) A 10k$\Omega$ resistor $R_1$ and a 5k$\Omega$ resistor $R_2$ combines in series so that their resistances add. If $R_1$ has an uncertainty of 500$\Omega$ and the uncertainty in $R_2$ is 400$\Omega$. What is the uncertainty in $R_1+R_2$?