

**Problem 1**

Draw the schematic for the CMOS circuit that implements the function  $F$  described by the truth table below. Use the least possible number of transistors. Explain your procedure and show the reduced function equation used to design the schematic.

Inputs			Output
X	Y	Z	F
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	1
1	1	0	0
1	1	1	1

**Problem 2**

Calculate the following for a sample of n-type silicon doped with  $N_d = 10^{15} \text{cm}^{-3}$ . Assume  $\mu_n = 1500 \text{cm}^2/\text{V-sec}$  and  $\mu_p = 500 \text{cm}^2/\text{V-sec}$

- $n_n$  (free carrier electrons)
- $p_n$  (free carrier holes)
- conductivity of the sample
- resistance if the material is 1cm long, 100 $\mu\text{m}$  wide, and 1 $\mu\text{m}$  thick.

**Problem 3**

A pMOS transistor has  $W = 1.5\mu\text{m}$  and  $L = 0.5\mu\text{m}$ . What is the oxide thickness of the gate capacitance,  $C_G$ , is 1fF? Express your answer in angstroms.

**Problem 4**

- Draw the cross-section (profile) of a 4-terminal nMOS transistor and label all important regions of the device.
- Draw the top view of a 4-terminal nMOS transistor showing all of the layout layers and features necessary to construct a complete *four-terminal* device.
- Repeat steps a) and b) for a pMOS transistor.
- Which step in the LOCOS process defines the channel width ( $W$ ) of a MOSFET?

**Problem 5**

List the SCMOS design rule (minimum size/dimension) in units of lambda ( $\lambda$ ) for the following layout features. You will have to visit the MOSIS design rules website, linked on the class/lab webpage.

- spacing between n-wells at same potential
- spacing between actives of different implant (doping type)
- poly overlap of active
- select overlap of contact
- contact size
- metal-1 spacing

**Problem 6**

Sketch a color-coded stick diagram for the circuit that implements the function  $f = \overline{a + b \cdot c + d}$ .

Organize the layout so that the transistors can be implemented on a continuous strip of active (i.e., do not break the active).