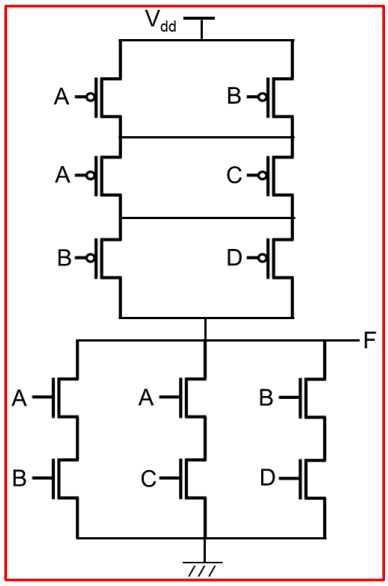
Homework Assignment 1
(Due Feb. 4th at the beginning of the class)

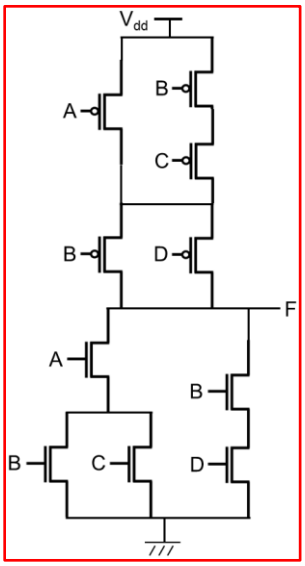
(1) [Static CMOS Circuit, **5 points**] Draw a transistor-level schematic for the following function. Use six NMOS and six PMOS transistors.

$$\boldsymbol{F = \overline{A \cdot B + A \cdot C + B \cdot D}}$$

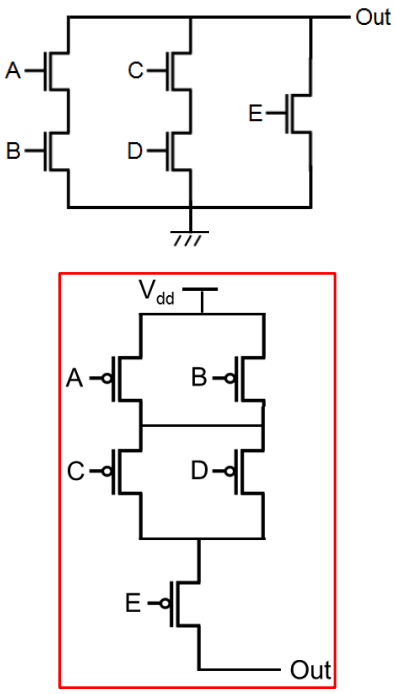


(2) **[**Static CMOS Circuit, **5 points**] Draw a transistor-level schematic for the above function. Use the smallest number of transistors.

$$\boldsymbol{F = \overline{A \cdot (B + C) + B \cdot D}} \textbf{ or } \boldsymbol{\overline{A \cdot C + B \cdot (A + D)}}$$

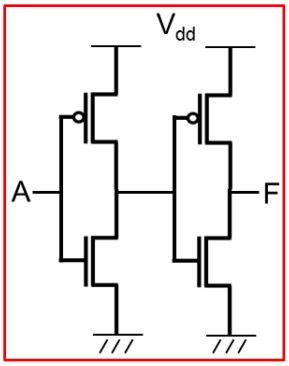


(3) **[**Static CMOS Circuit, **5 points**] An NMOS logic array for a function is shown below. Construct the PMOS circuit to complete the function.



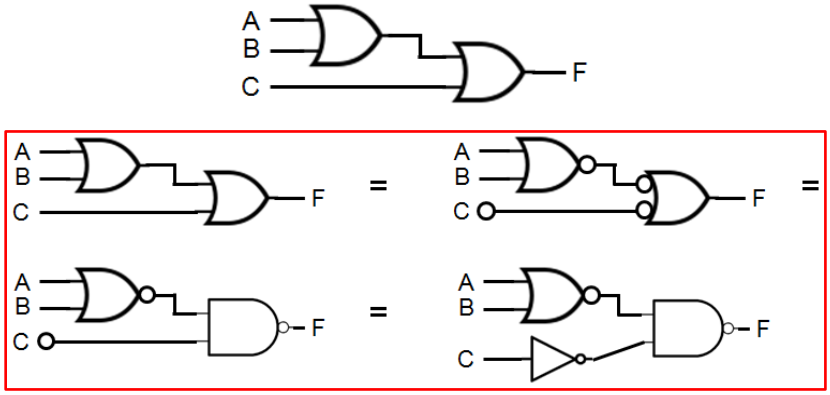
(4) **[**Static CMOS Circuit, **5 points**] Draw a transistor-level schematic for the following function.

$$\boldsymbol{F = A}$$



(5) **[**Logic Conversion, **5 points**] The two-input AND and OR gates use six transistors, but the two-input NAND and NOR gates use four transistors, so NAND and NOR gates are preferred to AND and OR gates in the design of CMOS circuits. Convert the following logic ($F = A + B + C$) into a new logic

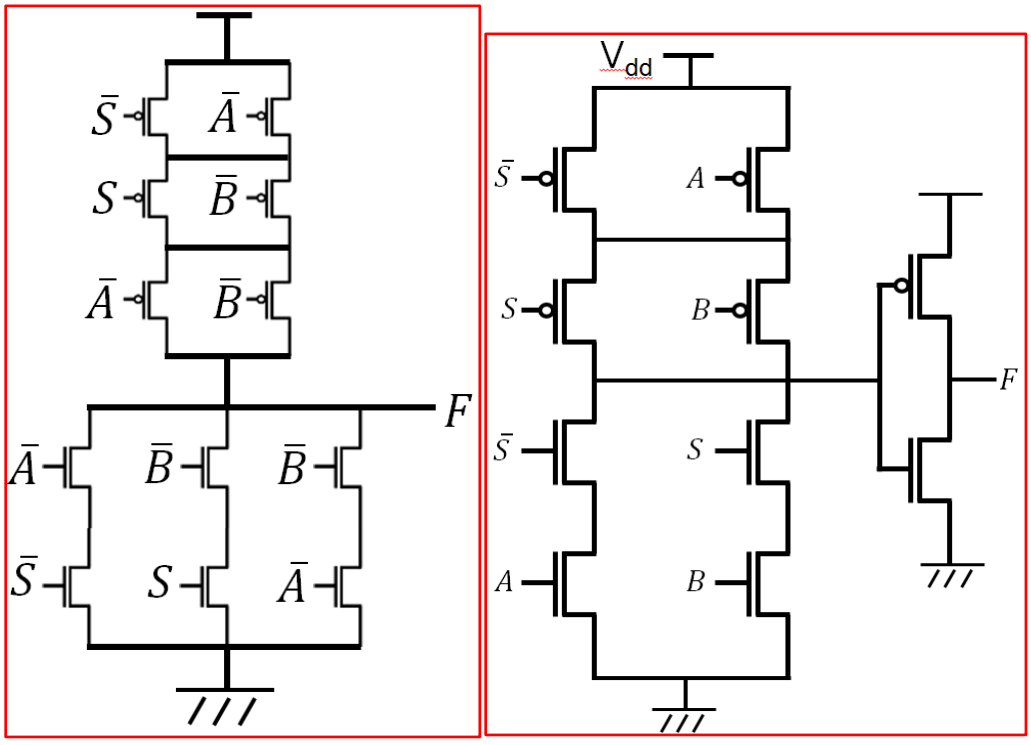
using only INV, two-input NAND, and two-input NOR gates. Use the smallest number of transistors.



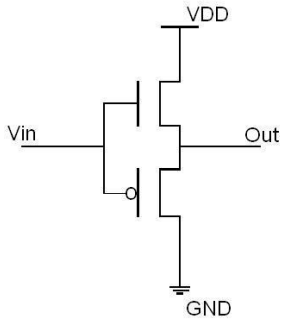
(6) **[**Static CMOS Circuit, **5 points**] Draw a transistor-level schematic for a two-input MUX ($F = \bar{S} \cdot A + S \cdot B$).

	S	
	0	1
F	A	B

$$F = \bar{S} \cdot A + S \cdot B = \overline{\overline{\bar{S} \cdot A + S \cdot B}} = \overline{(S + \bar{A}) \cdot (\bar{S} + \bar{B})} = \bar{S} \cdot \bar{A} + S \cdot \bar{B} + \bar{A} \cdot \bar{B}$$



(7) [CMOS gates, **5 points**] What is the intended function of the circuit shown in the figure below? What is the output swing?



Out = Vin. Swing = $[V_{tp}, V_{DD} - V_{tn}]$.

(8) [HSPICE simulation, **10 points**]

1. (Wn, Wp) = (90nm, 140nm): **tf=70ps, tr=69ps**
2. (Wn, Wp) = (180nm, 280nm): **tf=34ps, tr=34ps**
3. (Wn, Wp) = (90nm, 140nm), Cout=20fF: **tf=137ps, tr=138ps**
4. (Wn, Wp) = (90nm, 140nm), Cout=20fF, 50ps: **tf=137ps, tr=136ps**