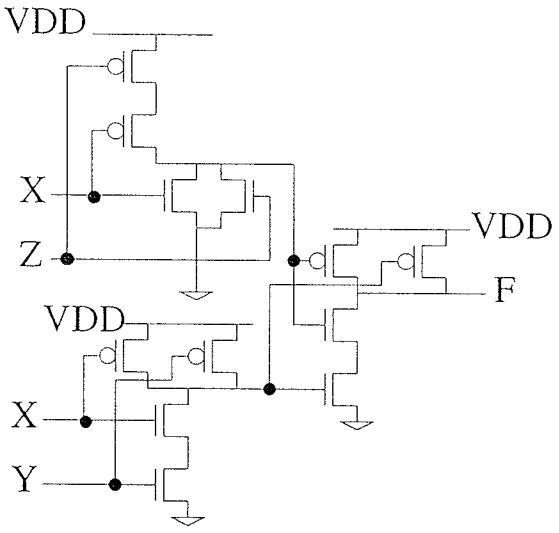
Modeling, Analysis, and Design of Combinational / Sequential Logic

1 Logic Function and Static CMOS Implementation (40 points)

1.1 Truth Table (8 points)

Consider the the circuit using static CMOS. What are the values of A and B (Low or High)?

Low = GND. High = Vdd.



X	Y	Z	F
Low	Low	Low	-
Low	Low	High	-
Low	High	Low	A
Low	High	High	-
High	Low	Low	-
High	Low	High	B
High	High	Low	-
High	High	High	-

1.2 Logic Function (24 points)

Write the function $F(X, Y, Z)$. The answer should be in the form of canonical sum (of minterms). A minterm is a product that includes all literals: X, Y, Z or their complements. The product $X \cdot Y \cdot \overline{Z}$, for example, is a minterm, but the product $X \cdot Y$ is not. Use $\overline{X}$ to express the complement of X. Notice that $\overline{XY} = \overline{X \cdot Y} = NOT(X \cdot Y)$ is different from $\overline{X} \cdot \overline{Y} = NOT(X) \cdot NOT(Y)$.

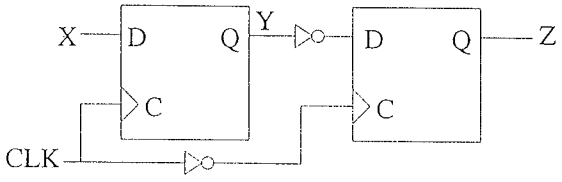
1.3 Logic Minimization (8 points)

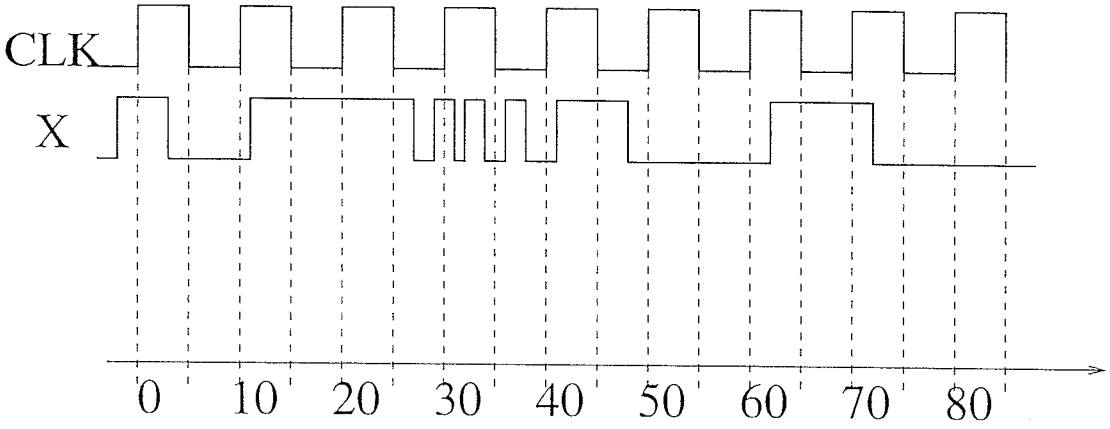
Minimize the logic expression. You should use the minimum number of literals.

2 Sequential Circuits (32 points)

Consider the output of the following sequential circuit with positive-edge-triggered D flip flops. Suppose the clock cycle is 10 ns with 50% duty cycle. **Ignore** the setup time of the flip flops, the delay of the inverter, and the delay of the wires.

Between 11ns and 76ns, how many times does Y change from Low to High? Between 11ns and 76ns, how many times does Z change from Low to High?





3 State Machine (28 points)

In this question, all numbers use **decimal representations**.

The following is an incomplete Moore state machine that outputs the remainder of 4 from an input stream of decimal numbers. If the present state is S0 and the input is 1, 5, or 9, the next state is S1 and the output is 1. If the present state is S1 and the input is 2 or 6, the next state is S0 and the output is 0. This can be understood by considering one example: If the input number is 52, the remainder of the first digit 5 is 1 (state S1). When the second digit 2 appears, the number is 52 and it is a multiple of 4. Hence, the output is 0. Assume the machine starts from S0 and the digits are scanned from MSD (most significant digit) to LSD (least significant digit).

Suppose the machine is now in state S1 after several input digits. Let y be a single-digit number that is the next input to the machine. List all possible values of y that will cause the machine to change to state S3 from the current state as shown in the thick arrow.