

1) Clock period analysis

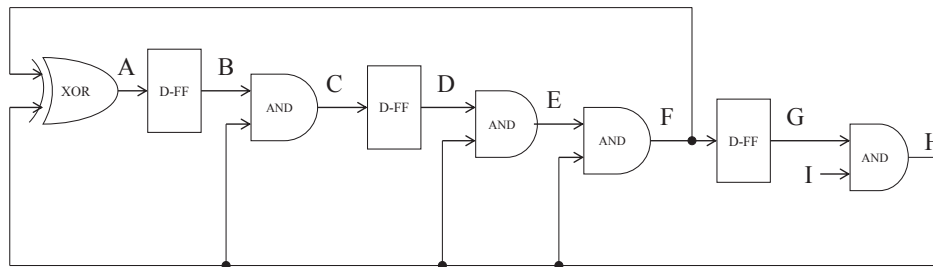
Consider the following sequential logic diagram where I is an **external input**.

Assume the gate delay is **2 ns** for a 2-AND gate and **3 ns** for a 2-XOR gate. Assume the positive edge-triggered flip-flop delay is $T_{delay_{FF}} = \mathbf{1\ ns}$, and setup time is also $T_{setup_{FF}} = \mathbf{1\ ns}$.

What is the **minimum clock period** that would satisfy these delays? Provide the critical path.

Clock period =

Critical path =



2) Sequential logic implementation

Consider the following Moore machine with initial state A. (“*” means don’t care.)

S_1S_0	$S_1^+S_0^+$				F
	$JK = 00$	$JK = 01$	$JK = 10$	$JK = 11$	
A	A	B	C	A	1
B	B	A	A	C	*
C	C	B	B	A	1

Assume the following state encoding.

State	S_1S_0
A	00
B	11
C	10

Fill-out the following K-Maps.

		S_1^+			
		00	01	11	10
S_1S_0	JK				
	00				
	01				
	11				
	10				

		S_0^+			
		00	01	11	10
S_1S_0	JK				
	00				
	01				
	11				
	10				

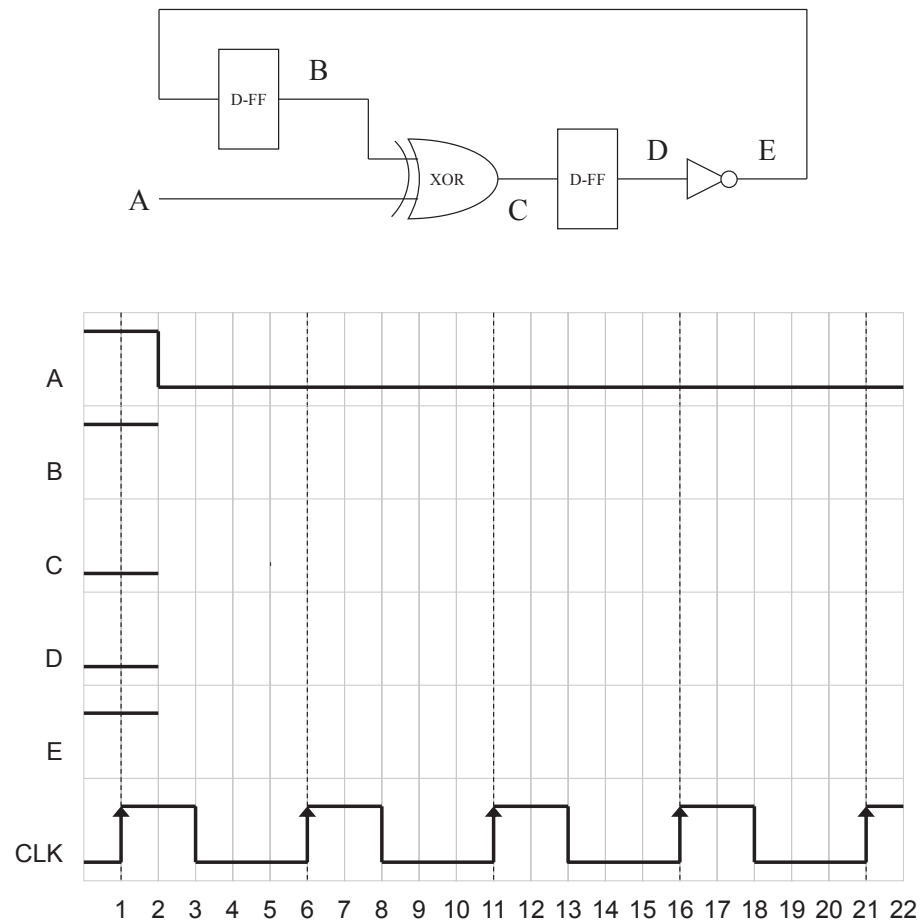
		F	
		0	1
S_1	S_0		
	0		
S_1	1		
	1		

3) Timing analysis

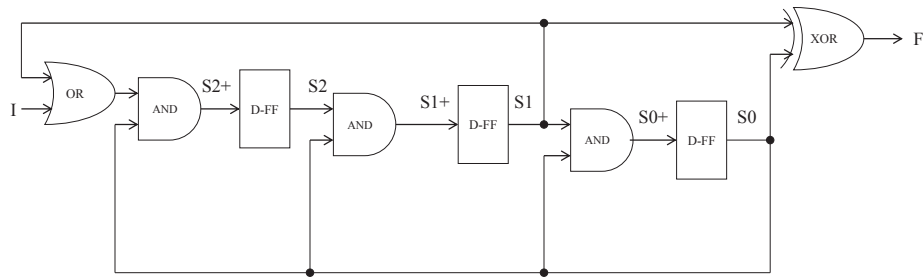
Consider the following sequential logic diagram.

Assume the gate delays are **1 ns** for XOR gates and INVERTERS. Assume the positive edge-triggered flip-flop delay is $T_{delay_{FF}} = \mathbf{1\ ns}$, and setup time is also $T_{setup_{FF}} = \mathbf{1\ ns}$.

Fill out the rest of the timing diagram for A , B , C , D , and E .



4) Reverse engineer sequential circuit to finite state machine



a) Fill out the following functions.

$$F =$$

$$S_2+ =$$

$$S_1 + \quad =$$

$$S_0 + \quad =$$

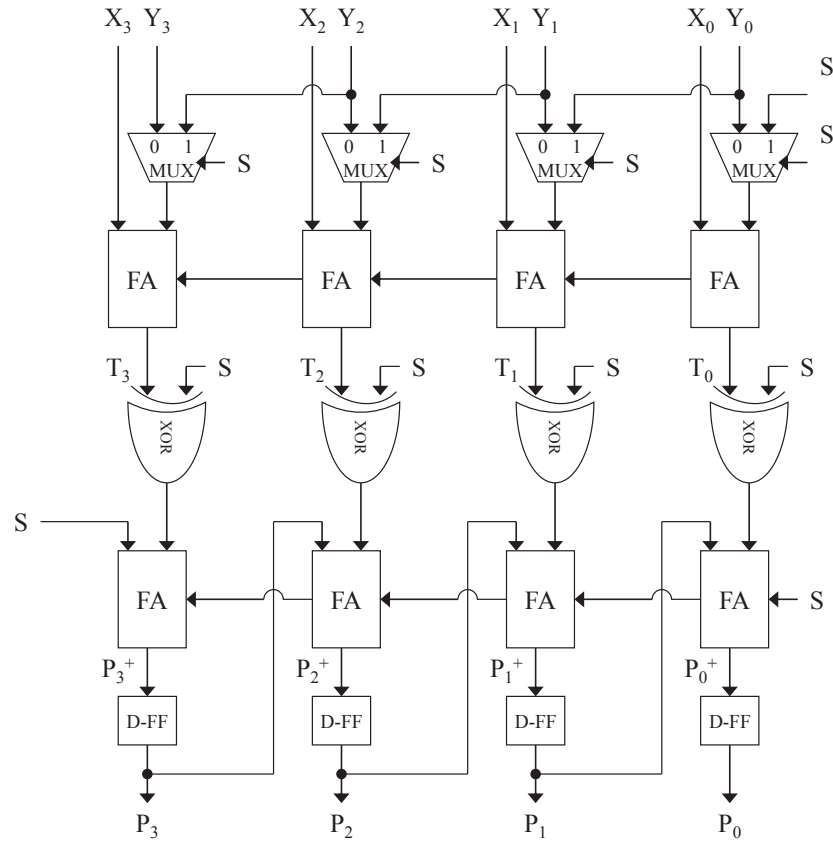
b) Assume initial state is 000, fill out the following state table. **Important: Only include reachable states in the state table.**

$S_2 S_1 S_0$	$S_2^+ S_1^+ S_0^+$		F
	$I = 0$	$I = 1$	

c) With initial state = **000**, what states, if any, are **not** reachable?

5) Datapath/registers

Consider the following diagram.



Given the values for control input S , the data inputs $X_3X_2X_1X_0$ and $Y_3Y_2Y_1Y_0$, and the flip-flop values $P_3P_2P_1P_0$, what will be the new flip flop values $P_3^+P_2^+P_1^+P_0^+$ be? $X_3X_2X_1X_0$, $Y_3Y_2Y_1Y_0$, and $P_3P_2P_1P_0$ are 2's complement numbers.

S	$X_3X_2X_1X_0$	$Y_3Y_2Y_1Y_0$	$P_3P_2P_1P_0$	$P_3^+P_2^+P_1^+P_0^+$
0	0011	0010	0011	
0	0010	0001	0001	
1	0000	0000	0000	
1	0001	0001	0001	