

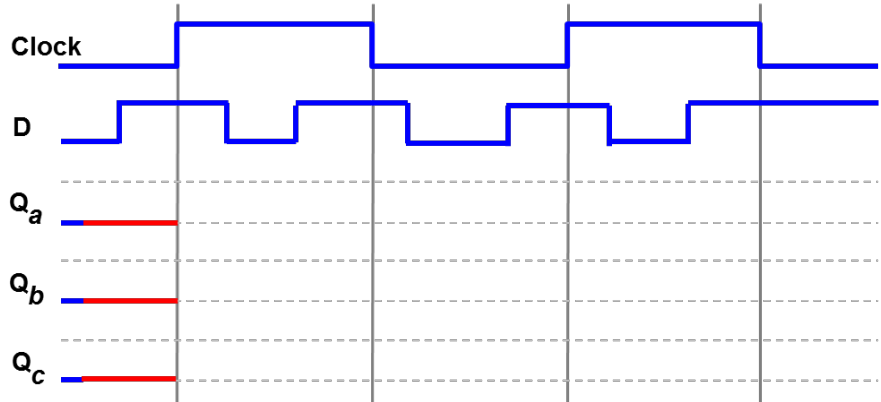
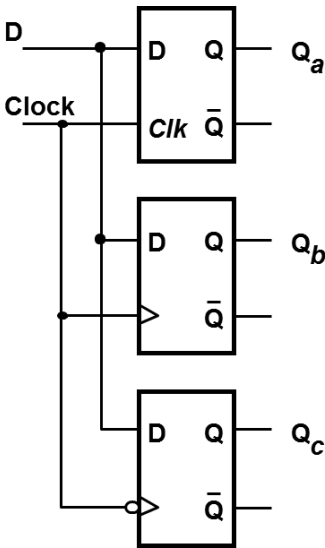
P1. (10 points)

Consider a basic SR latch with inputs S , R , and outputs Q_a , Q_b . (Figure 5.4 in the textbook)

- a) (5 points) What would happen to Q_a and Q_b if $S=R=1$?
- b) (5 points) What would happen to Q_a and Q_b if we transit from $S=R=1$ to $S=R=0$?

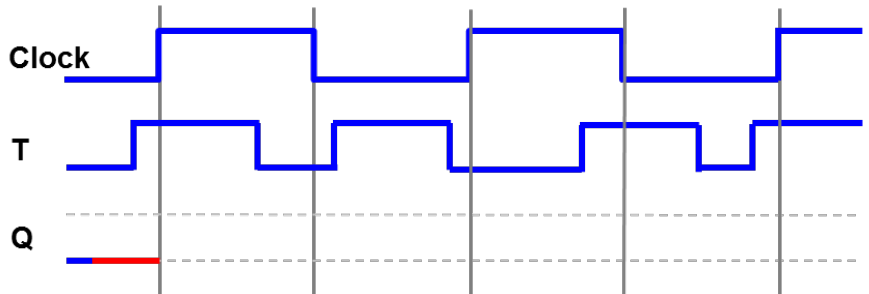
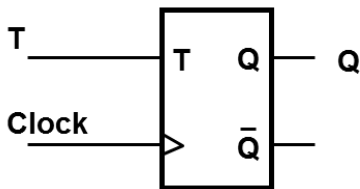
P2. (15 points)

Complete the following timing diagram for Q_a , Q_b , and Q_c , which are the outputs of a gated D latch, a positive edge-triggered D flip-flop, and a negative edge-triggered D flip-flop. Assume $Q = 0$ initially and no gate delays. (5 points each)



P3. (10 points)

Complete the following timing diagram for a T flip-flop. Assume no gate delays.



P4. (10 points)

The following truth table can be used to construct a T flip-flop using a D flip-flop.

T	Output		D
	Q(t)	Q(t+1)	
0	0	0	0
0	1	1	1
1	0	1	1
1	1	0	0

- (5 points) Write down the simplified SOP expression of D using T and Q(t) for inputs.
- (5 points) Draw the circuit for a T flip-flop using a D flip-flop and other necessary gates. Make sure you connect the flip-flop to a clock signal.

P5. (20 points)

Construct a JK flip-flop using a T flip-flop.

- (10 points) Complete the following truth table.

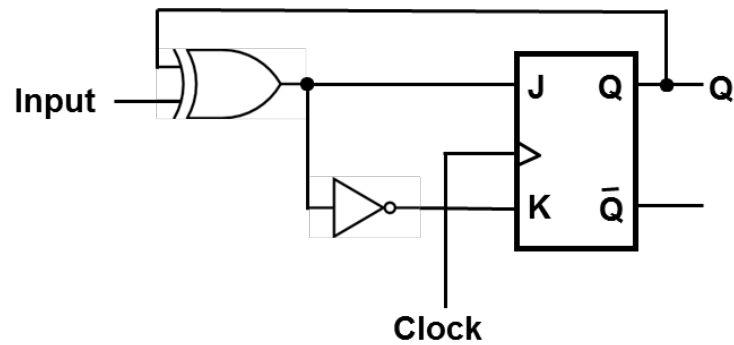
J	K	Output		T
		Q(t)	Q(t+1)	
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

- (5 points) Write down the simplified SOP expression of T using J, K, and Q(t) for inputs.
- (5 points) Draw the circuit for a JK flip-flop using a T flip-flop and other necessary gates. Make sure that you connect the flip-flop to a clock signal.

P6. (20 points)

Design a 4-bit shift register that has a control input S, a data input X, and output Q₃Q₂Q₁Q₀. When S=0, the register will shift left, i.e., the output becomes Q₂Q₁Q₀X. When S=1, the register will shift right and the output becomes XQ₃Q₂Q₁. Draw a circuit for such a shift register using 4 D flip-flops and 4 2-to-1 multiplexers.

P7. (15points)



a) (10 points) Complete the truth table for the circuit above.

Input	$Q(t)$	J	K	$Q(t+1)$
0	0			
0	1			
1	0			
1	1			

b) (5 points) Based on the truth table, could you identify which flip-flop it is?