Circuits w/ memory   Sequential Circuits

Up to today   output = $f(\text{input})$ combinational

output = $f(\text{input}, \underline{\text{state}})$ sequential

- memory of past inputs
- current step in a process
- hidden stored binary number
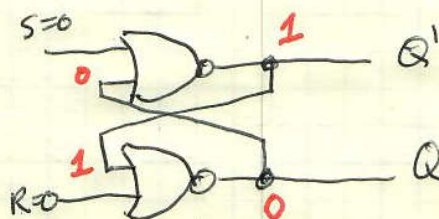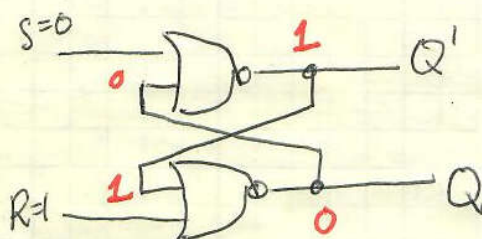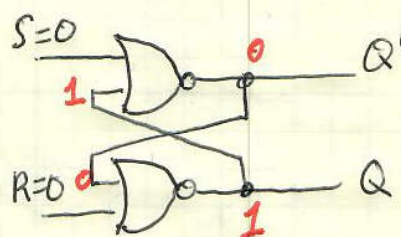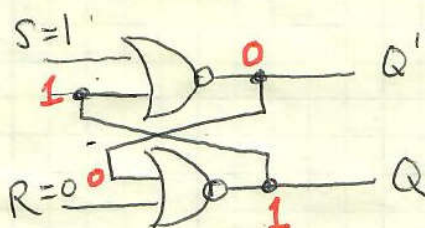
Let's look @ an example: Cross coupled NORs

SR latch   S = Set = make a value 1
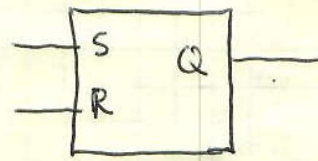   R = Reset = make a value ϕ

Truth Table for NOR

a	b	$(a+b)'$
0	0	1
0	1	0
1	0	0
1	1	0

if either input is 1 output is ϕ
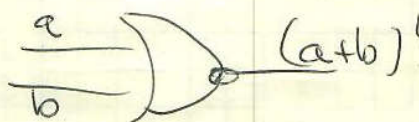
How \ When	Latch	Clock Latch	Flip Flop
D			
T			
SR			
JK			

S	R	Q^+	
0	0	Q	hold
0	1	0	reset
1	0	1	set
1	1	X	forbidden

SR latch

Basic Memory Elements

Store 1 bit of information

Stored bit is output on Q

Characterized by 2 attributes

<u>When</u> they sample data input

<u>How</u> they convert data input into stored bit

<u>When</u>   <u>Latch</u>   always sampling data input

        <u>Clock latch</u>   samples data input when clk input = 1

        <u>flip flop</u>   samples data input when clk input ↑

<u>How</u>

D	Q^+
0	0
1	1

T	Q^+
0	Q
1	Q'

S	R	Q^+
0	0	Q
0	1	0
1	0	1
1	1	X

J	K	Q'
0	0	Q
0	1	0
1	0	1
1	1	Q'

Complete the timing diagram.