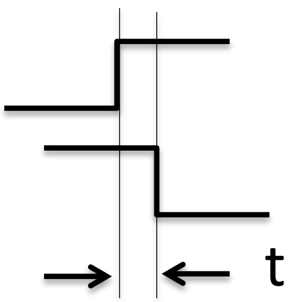
Physics 623
Lecture 26 March

- HW 8 due Tuesday 1pm
- Lab next week “Digital Circuits”
- —Prelab due Wednesday 3pm
- Exam II delayed until Tue Apr 7
  —(instructions from L&S)
- email me an address suitable for UPS delivery. Include your phone number.

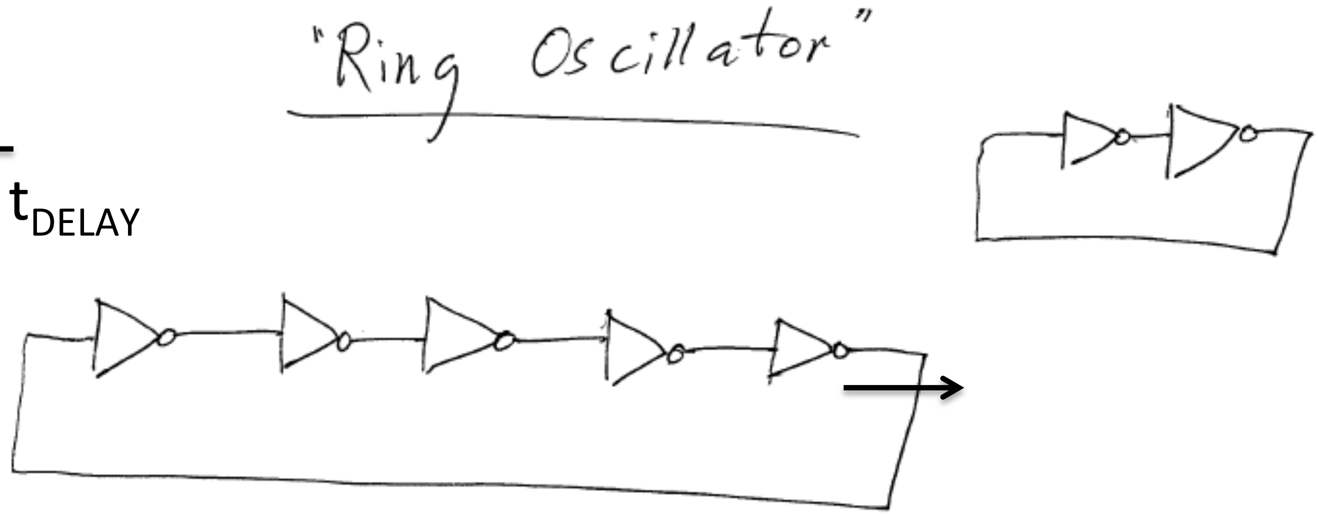
Today:

Memory and Sequential Logic

Propagation time from changing the input of a gate to the output changing in response is called "delay time", or t_{DELAY}.



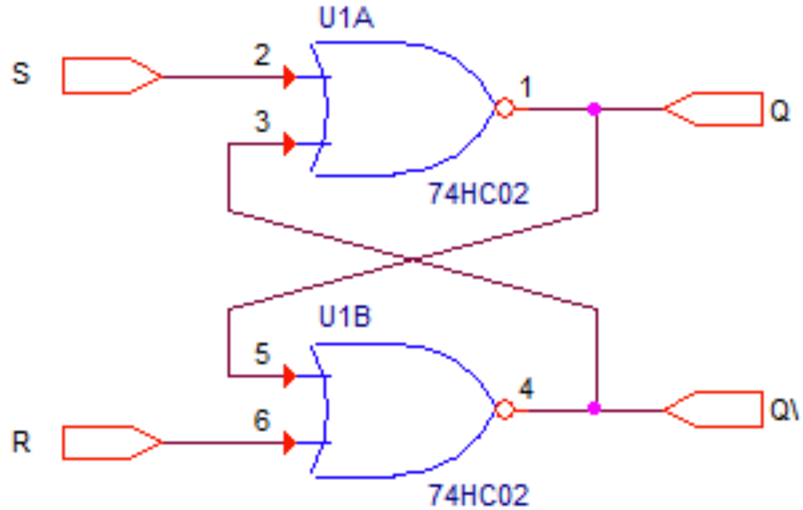
t_{DELAY}



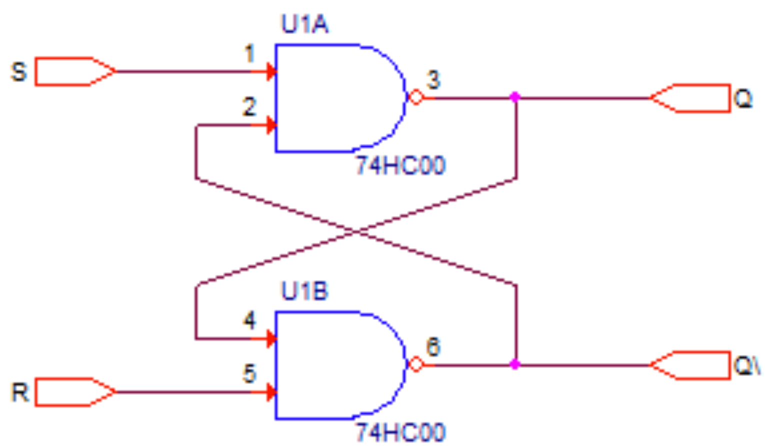
Period = 2N x t_{DELAY} (f = 1/Period)

What if the desired output depends not only on the current state of the inputs, but also on something that happened in the past? This is called “sequential logic”, vs. the “parallel logic” that can be completely specified by a truth table.

We need a ***memory!***

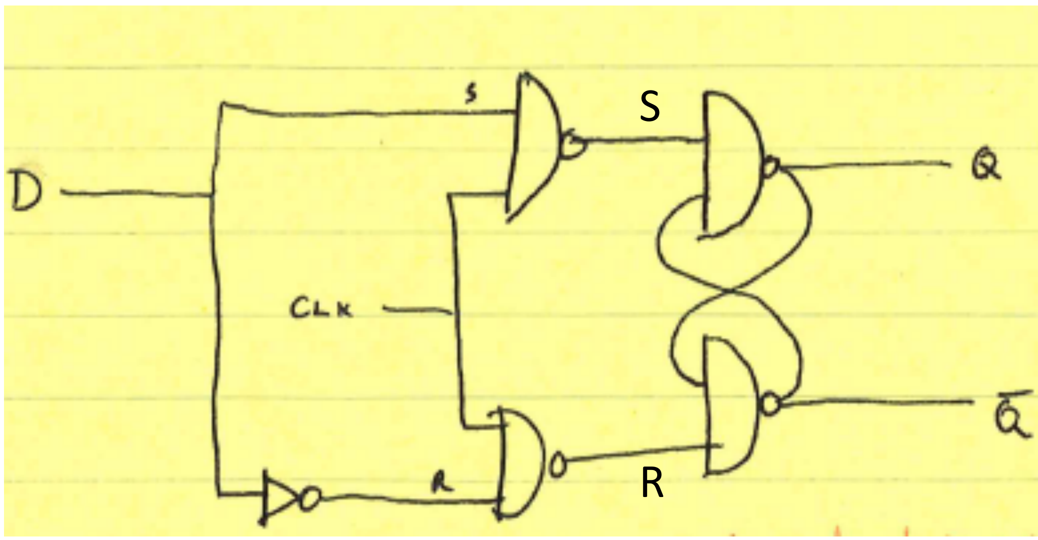


S	R	Q	Q'
0	0	no change	
1	0	1	0
0	1	0	1
0	1	forbidden	



S	R	Q	Q'
1	1	no change	
0	1	1	0
1	0	0	1
0	0	forbidden	

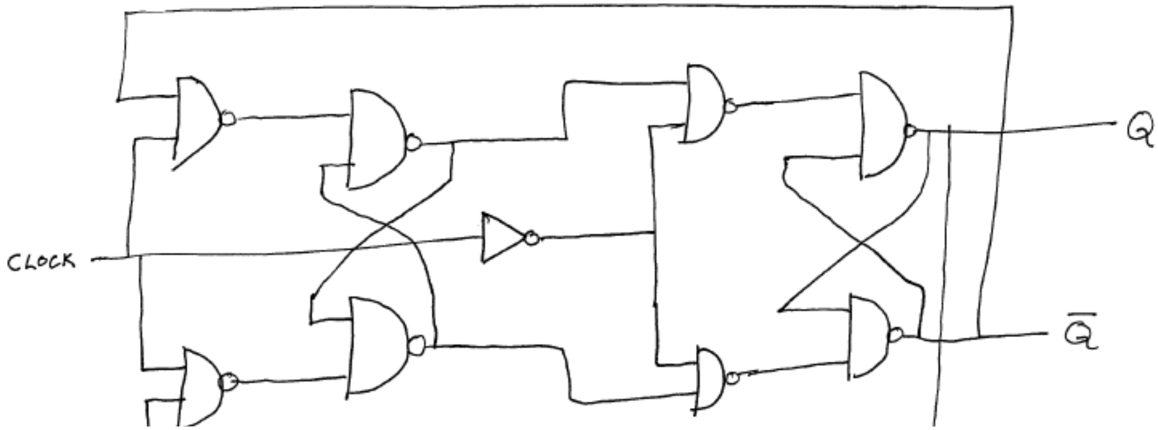
Gated Flip-Flop

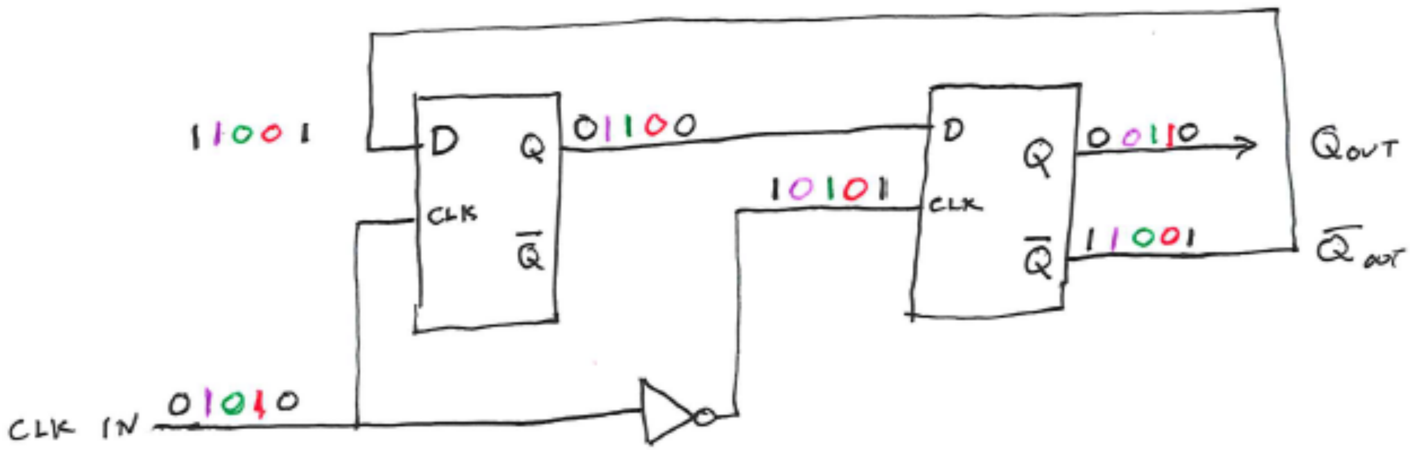


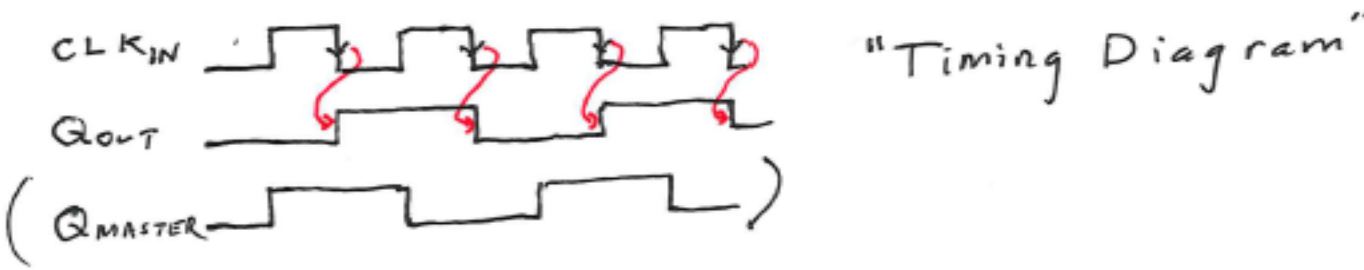
S	R	Q	Q'
1	1	no change	
0	1	1	0
1	0	0	1
0	0	forbidden	

"Data Latch"

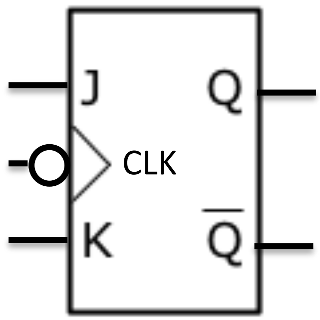
“Edge-triggered” flip-flop:

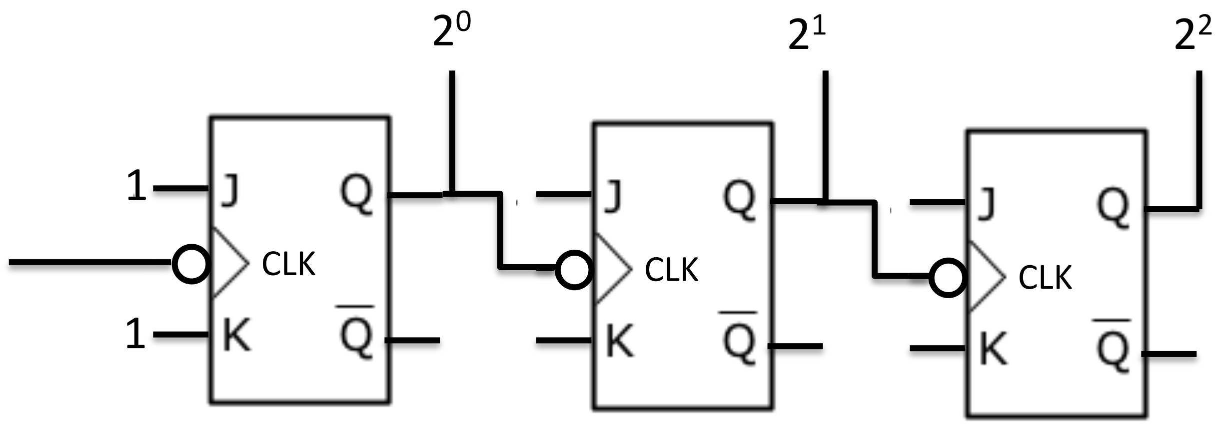




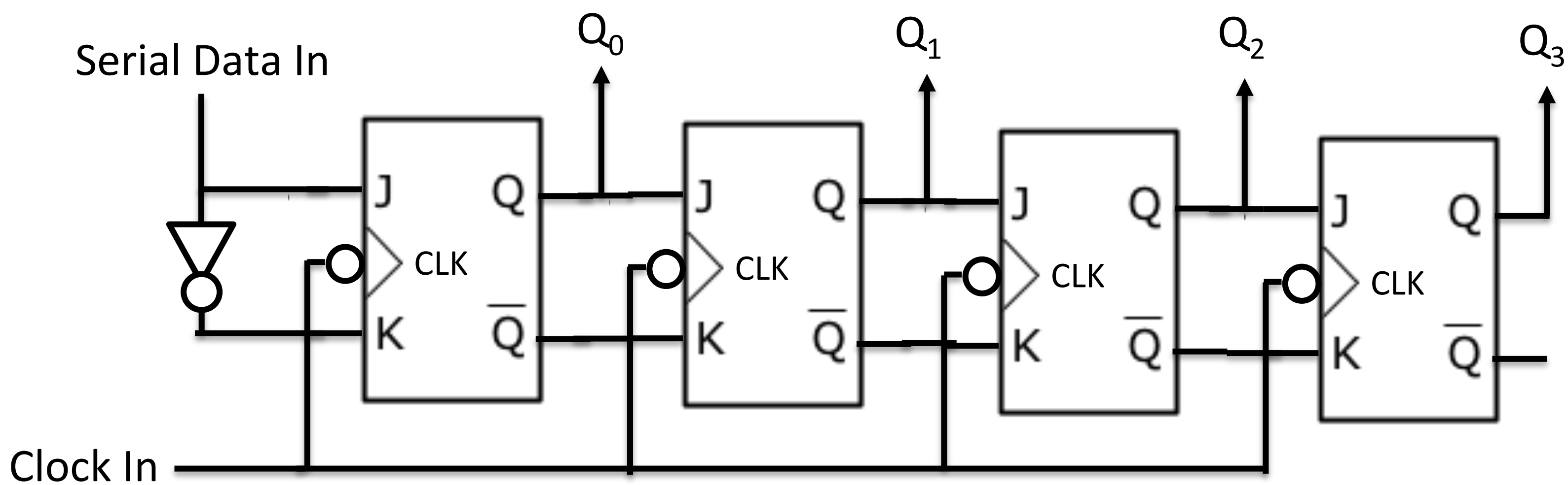


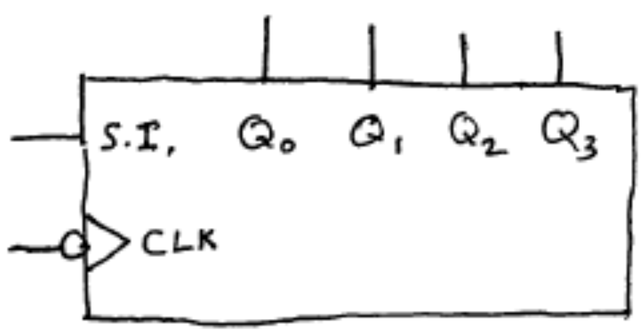
J	K	Q_{n+1}
0	0	Q_n
0	1	0
1	0	1
1	1	$\overline{Q}_n$



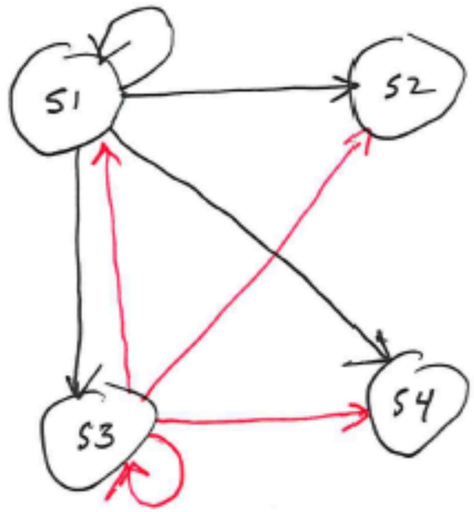


"Shift Register"





State Machines



Where you are					State after event	
S_0	S_1	A	B	C	S_0'	S_1'

Can be T or F → A B C

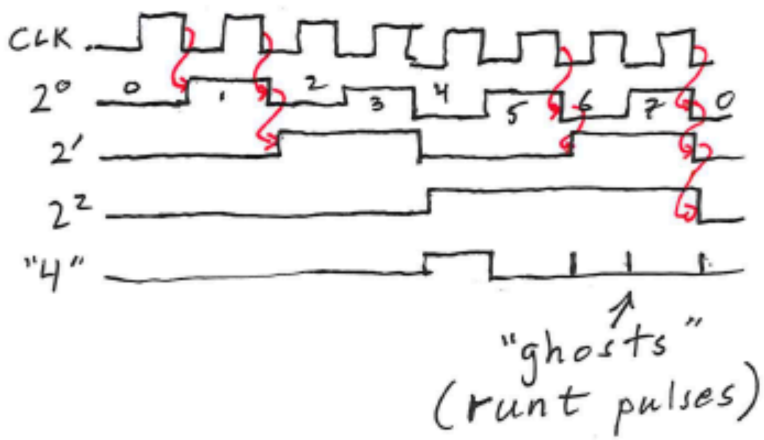
State Machines

1. If have N states, need memory to remember which state you are currently in. Could have N flip-flops — ~~the~~ one for each state, only one ON at a time. Minimum requirement is $\log_2(N)$ Flip Flops to encode binary number of state.

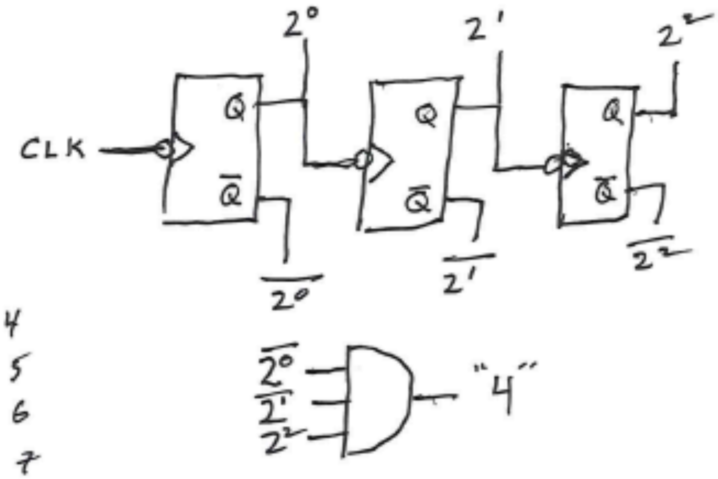
2. Have one or more inputs indicating an "event" has occurred. Often this is just a clock.

3. Need a set of rules, telling what state to go to, ~~given~~ when an event occurs, depending on a) the current state b) the event that occurred and c) the T or F values of other inputs. PARALLEL LOGIC - TRUTH TABLE

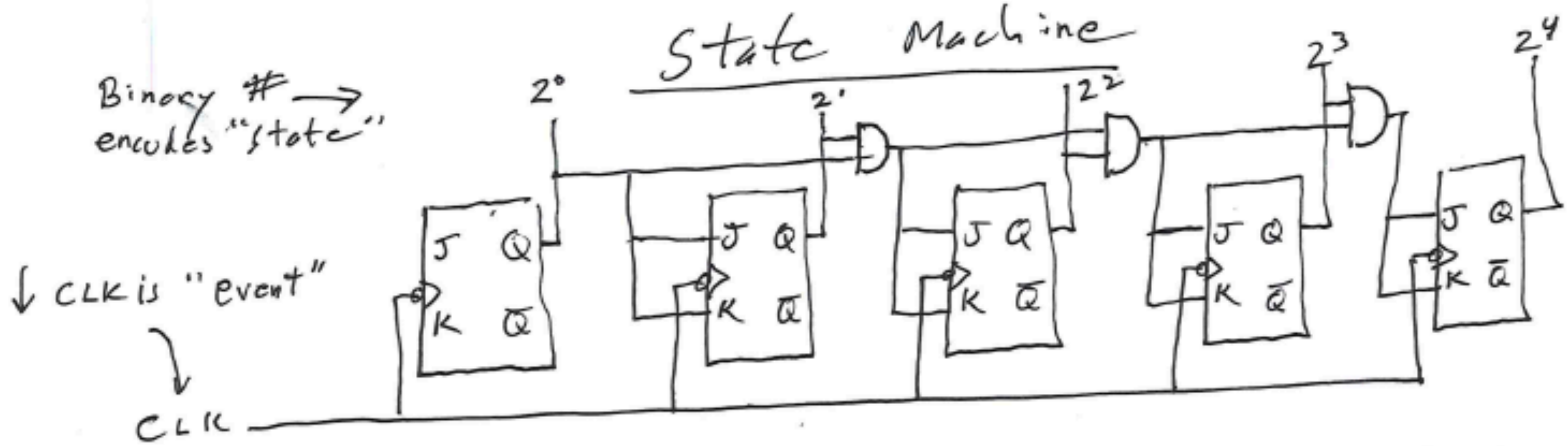
Example - Synchronous Counter



2^2	2^1	2^0	
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	4
1	0	1	5
1	1	0	6
1	1	1	7



State Machine



Rules: change state of bit if all bits to left = 1
stay same otherwise