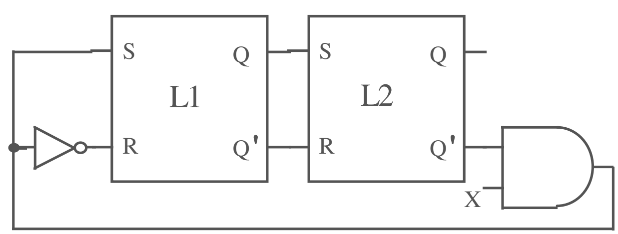
Outline

- ❍ **Last time:**
  - ➜ Asynchronous Circuits
  - ➜ Moore and Mealy Standard Forms
  - ➜ Design Example: Word Problem
  - ➜ Race-free State Assignment
  - ➜ Excitation Equations
  - ➜ Design Example: Implementation
  - ➜ Summary of Asynchronous Design Process
- ❍ **This lecture:**
  - ➜ **Examples for Review**

Race Conditions and Cycles



Q_1Q_2 \ X	0	1
00	00	10
01	00	00
11	01	01
10	01	11

Q_1Q_2 \ X	0	1
00	00	
01	00	
11	01	
10	01	11

Race Conditions

Q_1Q_2 \ X	0	1
00	00	11
01	00	01
11	01	11
10	10	10

Word Problem Review - Example 1

"A sequential network has two inputs (X_1,X_2) and one output (Z). The output remains a constant value unless one of the following input sequences occurs:

(a) Sequence X_1X_2 = 01, 11 causes 0 output.
(b) Sequence X_1X_2 = 10, 11 causes 1 output.
(c) Sequence X_1X_2 = 10, 01 causes the output to change value.

Derive a Moore state graph for the network which contains the minimum number of states."

Word Problem Review - Example 1

❍ **Observations:**

➔ **The only sequence of input pairs which affect the output are of length two. Therefore, the previous and present inputs will determine the output, so the network only has to "remember" the previous input pair.**

➔ **First glance, it looks like 3 states are needed, to remember 01, 10, and {00 or 11}. It is unnecessary to use separate states for 00 and 11 since neither input starts a sequence leading to an output change. However, for each of these states the output could either be 0 or 1, so start with 6 states in the table.**

Word Problem Review - Example 1

previous input (X_1X_2)	output (Z)	state designation
00 or 11	0	S0
00 or 11	1	S1
01	0	S2
01	1	S3
10	0	S4
10	1	S5

X_1X_2

P.S.	00	01	11	10	Z
S0	S0	S2	S0	S4	0
S1	S1	S3	S1	S5	1
S2	S0	S2	S0	S4	0
S3	S1	S3	S0	S5	1
S4	S0	S3	S1	S4	0
S5	S1	S2	S1	S5	1

N.S.

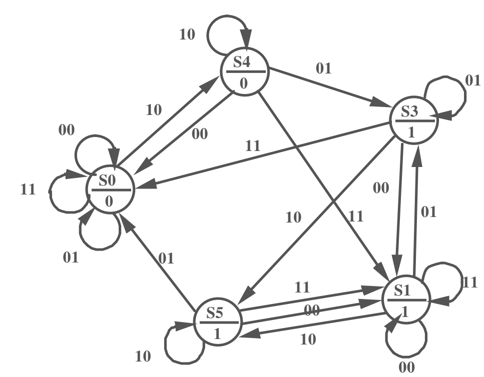
Word Problem Review - Example 1

S1	X				
S2	✓	X			
S3	X	S0-S1	X		
S4	S2-S3 S0-S1	X	S2-S3 S0-S1	X	
S5	X	S2-S3	X	S2-S3 S0-S1	X
	S0	S1	S2	S3	S4

P.S.	00	01	11	10	Z
	X_1X_2				
S0	S0	S0	S0	S4	0
S1	S1	S3	S1	S5	1
S3	S1	S3	S0	S5	1
S4	S0	S3	S1	S4	0
S5	S1	S0	S1	S5	1
	N.S.				

Replace state S2 with state S0

Word Problem Review - Example 1



Word Problem Review - Example 2

"A sequential network has one input (X) and one output (Z). The output should be 1 if the input sequence ends in either 010 or 1001, and Z should be 0 otherwise.

Derive a Mealy state graph for the network which contains the minimum number of states."

X = 0 0 1 0 1 0 0 1 0 0 0 1 0 0 1 1 0

Z = 0 0 0 1 0 1 0 1 1 0 0 0 1 0 1 0 0

a b c d e f

Word Problem Review - Example 2

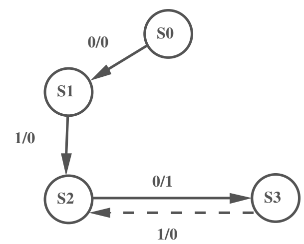
❍ **Observations:**

➔ **Begin by working with the two sequences which lead to a 1 output.**

➔ **Start with the reset state S0 corresponding to having received no inputs.**

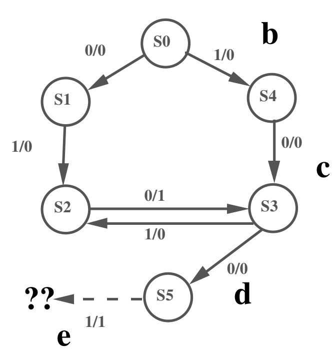
Word Problem Review - Example 2

sequence received	state designation
reset	S0
0	S1
01	S2
010	S3



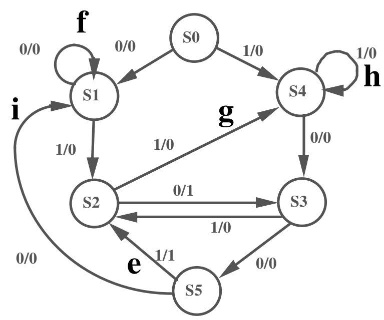
Word Problem Review - Example 2

sequence ends in	state designation
reset	S0
0	S1
01	S2
010 or 10	S3
1	S4
100	S5

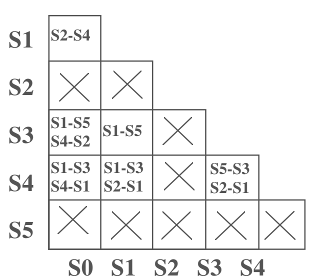


Word Problem Review - Example 2

sequence ends in	state designation
reset	S0
0	S1
01	S2
010 or 10	S3
1	S4
100	S5



Word Problem Review - Example 2



	X	
P.S.	0	1
S0	S1/0	S4/0
S1	S1/0	S2/0
S2	S3/1	S4/0
S3	S5/0	S2/0
S4	S3/0	S1/0
S5	S1/0	S2/1

N.S./O

Example 3: Asynchronous Analysis

(a) Analyze the following asynchronous network using a flow table. Starting in the stable total state state for which X=Z=0, determine the state and the output sequences when the input sequence is X=0, 1, 0, 1, 0,...

(b) Find any critical races which are present in the table.