Switching Circuits and Logic Design
CS21002 (section-1)
Tutorial 3

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1. Analyze the synchronous circuit of Fig. 1 (the clock is not shown, but is implicit).
   (a) Write down the excitation and output functions. (Recall that excitation functions are the ones that describe the effect of the circuit inputs and the state variables on the memory element inputs, and the output functions are the ones that describe the effect of the circuit inputs and the state variables on the circuit output)
   (b) Give a word description of the circuit operation.

2. A long input sequence enters a one-input one-output synchronous sequential circuit, that is required to produce an output symbol $z = 1$ whenever the sequence 1111 occurs. Overlapping sequences are accepted; for example, if the input sequence is 01011111, the required output sequence is 00000011 . . ..
   (a) Draw a state diagram.
   (b) Select a state-assignment (recall that a state-assignment assignes the states of your abstract machine to the physical states of your memory elements) and show the excitation and output tables.
   (c) Write down the excitation functions for SR flip-flops, and draw the corresponding logic diagram.
   (d) Repeat part (c) with T flip-flops instead.

3. For each of the following cases, show the state table that describes a one-input one-output machine having the following specifications.
   (a) An output symbol $z = 1$ is to be produced to coincide with every occurrence of the input symbol 1 following a string of two or three consecutive 0s at the input. At all other times, the output symbol is to be 0.
   (b) Regardless of the input symbols, the first two output symbols are 0s. Thereafter, output symbol z is a replica of input symbol x but delayed by two time units, that is, $z(t) = x(t - 2)$ for $t \geqslant 3$.
   (c) The output $z(t)$ is 1 if and only if $x(t) = x(t - 2)$. At all other times, z is to be 0.
   (d) The output z has the value 1 whenever the last four input symbols correspond to a BCD number that is a multiple of 3, i.e., $0, 3, 6, \ldots$

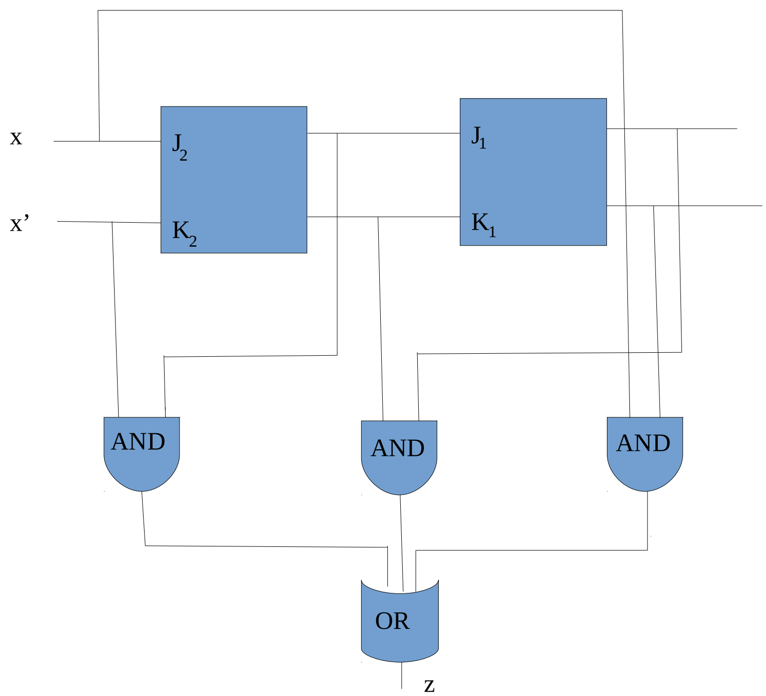

Figure 1:

4. Consider a clocked memory device having one binary input Y and one binary output y. If $Y(t) = 0$ then $y(t+1) = 0$; if $Y(t) = 1$ then $y(t+1) = y'(t)$. The following state table given is to be realized using two such memory devices. Choose an appropriate state assignment and give the corresponding excitation and output equations.

State	x=0	x=1
A	B,0	B,0
B	C,0	A,1
C	B,0	D,0
D	C,0	B,1

5. Prove that $n(n-1)/2$ is an upper bound on the length of the shortest input sequence that will take a strongly connected n-state machine through each of its states at least once, regardless of the initial state. Is this the least upper bound?

6. An n-state machine is supplied with a periodic input sequence whose period is p. Prove that the output sequence must eventually become periodic.

7. Prove that there exists no finite-state machine that accepts precisely all those sequences that read the same forward as backward, i.e., sequences that are their own reverses. (Such sequences are called palindromes.)

8. Determine which of the machines with the following specifications is realizable with a finite number of states. If any machine is not realizable, explain why.
(a) A machine is to produce an output symbol 1 whenever the number of 1s in the input sequence, starting at $t = 1$, exceeds the number of 0s. For example, if the input sequence is 01100111, the required output sequence is 00100011.
(b) A machine with a single input line and 10 output lines numbered 0 through 9 is to be designed such that, following the n-th input symbol, only one output symbol 1 will be produced on the line whose corresponding number is equal to the nth digit of π (i.e., $3.14\ldots$). The following fact may be useful: π is irrational.

9. For each of the following 3 machines, find the equivalence partition and the reduced machine.

State	x=0	x=1
A	B,0	E,0
B	E,0	D,0
C	D,1	A,0
D	C,1	E,0
E	B,0	D,0

State	x=0	x=1
A	F,0	B,1
B	G,0	A,1
C	B,0	C,1
D	C,0	B,1
E	D,0	A,1
F	E,1	F,1
G	E,1	G,1

State	x=0	x=1
A	D,0	H,1
B	F,1	C,1
C	D,0	F,1
D	C,0	E,1
E	C,1	D,1
F	D,1	D,1
G	D,1	C,1
H	B,1	A,1

10. Attempt other exercise problems of chapters 9 and 10 of Kohavi-Jha.