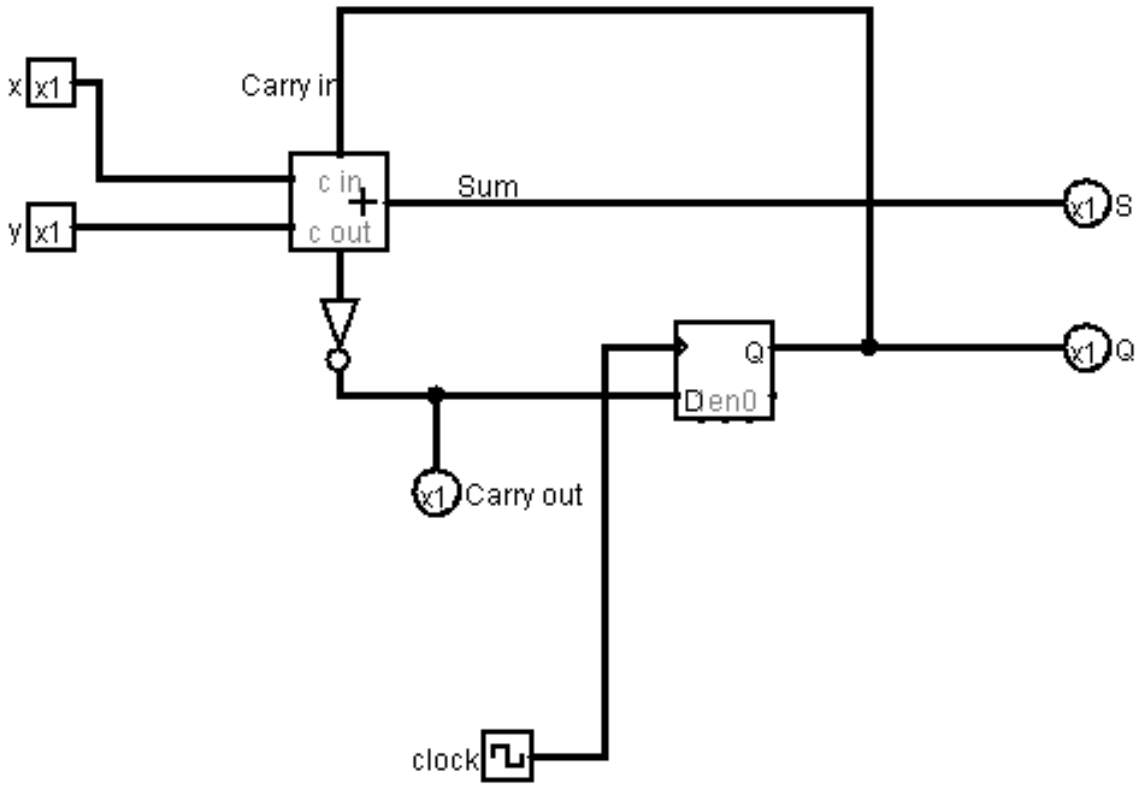
Autumn 2022, Homework 6 Key

Q1 (2 pts) Design a 1-bit memory of a full-adder.
The following sequential circuit includes a full-adder (described in the previous question). Inputs are X, Y and carry-in, and outputs are the next state of S and Q.

Implement the sequential circuit in Logisim simulator.



Through the Logisim simulation of this sequential circuit, complete the following truth table for this 1-bit memory of a full-adder: Note that the Carry out signal is output, not the input. The carry in signal is the same as the Q. You can change the Carry-in bit by clicking the D-FF.

X	Y	Carry-in (or Q before clock)	S (before clock)	Carry-out (before clock)	S (after clock)	Carry-out (after clock)
0	0	0	0	1	1	1
0	0	1	1	1	1	1
0	1	0	1	1	0	0
0	1	1	0	0	1	1
1	0	0	1	1	0	0
1	0	1	0	0	1	1
1	1	0	0	0	0	0
1	1	1	1	0	0	0

Grading guide: wrong value in any row, -0.5. When there are more than three wrong rows, give 0.5.

Q2. (4 pts) Design a sequential circuit.

A sequential circuit has one D flip-flop and one JK-flip-flop, two inputs x and y, and one output z. A and B are the outputs of each D flip-flop, and JK-flip-flop, respectively. The flip-flop ***input*** equations and the circuit output are as follows. Here D_A is the D input of the D-flip flop of A, and J_B, K_B is the J and K input of the JK-flip flop of B.

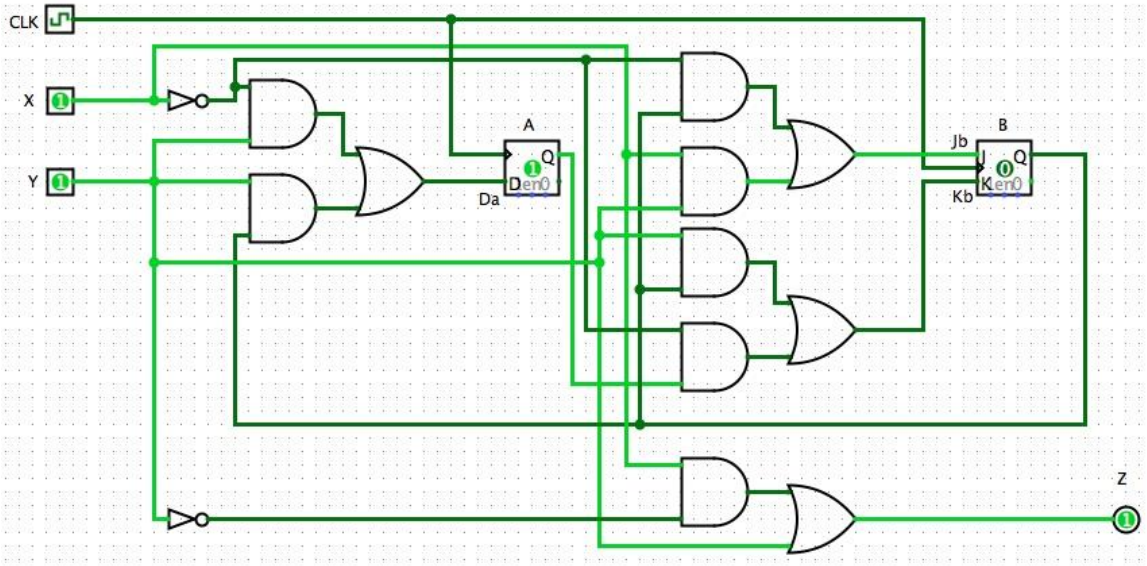
$D_A = \sim xy + yB$

$J_B = \sim xB + xy$

$K_B = yB + \sim xA$

$z = y + x\sim y$

Q2-1. (1pt) Draw the logic diagram of the circuit and test it with Logisim. Please attach the circuit image only, (i.e., capture the circuit image and attach it to your submission file. No need to include .circ.)



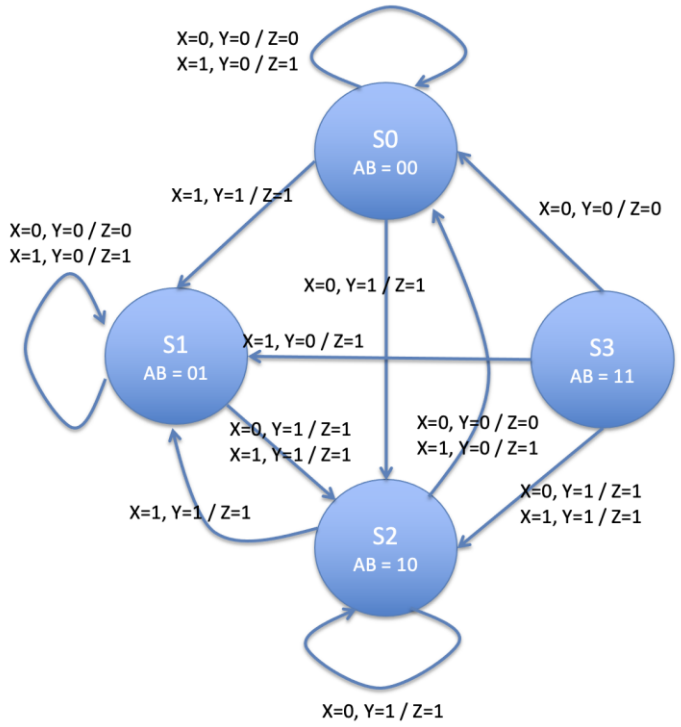
Grading guide: The circuit does not need to be the same. If the circuit picture is not included, -1.

Q2-2. Construct a state transition table as well as a state diagram of this circuit. Note that you don't have to simplify states. **(1pt)**

X	Y	A(t)	B (t)	A(t + 1)	B(t + 1)	Z
0	0	0	0	0	0	0
0	0	0	1	0	1	0
0	0	1	0	0	0	0
0	0	1	1	0	0	0
0	1	0	0	1	0	1
0	1	0	1	1	0	1
0	1	1	0	1	0	1
0	1	1	1	1	0	1
1	0	0	0	0	0	1
1	0	0	1	0	1	1
1	0	1	0	0	0	1
1	0	1	1	0	1	1
1	1	0	0	0	1	1
1	1	0	1	1	0	1
1	1	1	0	0	1	1
1	1	1	1	1	0	1

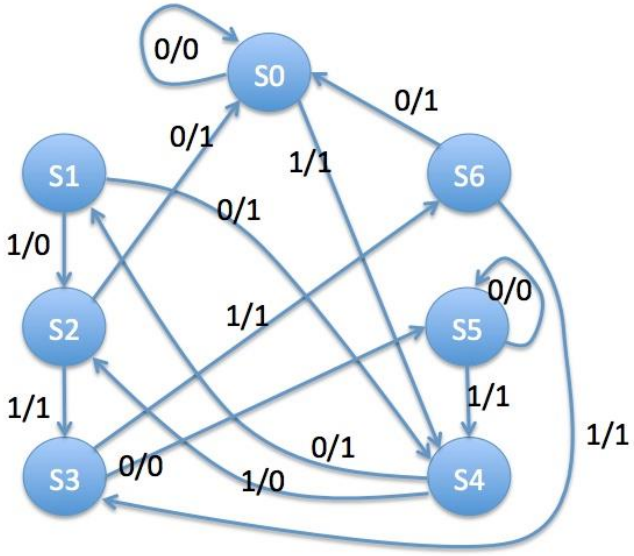
Attach a state diagram here. (3 pts)

Grading guide: wrong value in any row, -0.5. When there are more than four wrong rows, give 1.



Q3. (14pts) Design a sequential system by simplifying the states.

Q3-1. (4 pts) Draw the corresponding state transition table with 7 states (i.e., S0-S6) and simplify it to the one with 4 states. (Refer to pages 9 and 10 of Lecture Note: 12.SeqCircuit.pptx).



Hint: focus on a pair of S0 and S5; a pair of S1 and S4; and a pair of S2 and S6

(2 pts) The original state transition table

	Input X = 0		Input X = 1	
Current State	Next State	Output Z	Next State	Output Z
S0	S0	0	S4	1
S1	S4	1	S2	0
S2	S0	1	S3	1
S3	S5	0	S6	1
S4	S1	1	S2	0
S5	S5	0	S4	1
S6	S0	1	S3	1

Grading guide: wrong value in any row, -0.5. When there are more than three wrong rows, give 0.5.

(2 pts) A simplified state transition table

	Input X = 0		Input X = 1	
Current State	Next State	Output Z	Next State	Output Z
S0S5	S0S5	0	S1S4	1
S3	S0S5	0	S2S6	1
S1S4	S1S4	1	S2S6	0
S2S6	S0S5	1	S3	1

Grading guide: wrong value in any row, -0.5. When there are more than three wrong rows, give 0.5.

Q3-2. (2 pts) Allocate 2 JK flip-flops (A and B) to this simplified state transition diagram as following page 11 of 12.SeqCircuit.pptx.

Q(t)	Q(t+1)	J	K
0	0	0	*
0	1	1	*
1	0	*	1
1	1	*	0

	input X=0		input X=1		input X=0		input X=1		input X=0		input X=1	
Current State	Next State	Output Z	Next State	Output Z	JK Flip-Flop A				JK Flip-Flop B			
AB	AB	Z	AB	Z	Ja	Ka	Ja	Ka	Jb	Kb	Jb	Kb
S0S5=00	00	0	11	1	0	*	1	*	0	*	1	*
S3 = 01	00	0	10	1	0	*	1	*	*	1	*	1
S1S4=11	11	1	10	0	*	0	*	0	*	0	*	1
S2S6=10	00	1	01	1	*	1	*	1	0	*	1	*

Grading guide: wrong value in any row, -0.5. When there are more than three wrong rows, give 0.5.

Q3-3. (4 pts) Determine and simplify Boolean equations to these two JK flip-flops' inputs, (i.e., Ja/Ka, and Jb/Kb) using K-maps, as following page 12 of 12.SeqCircuit.pptx.

Grading guide: 1 point for each K-map and the corresponding Boolean equation. If the K-map is wrong but the Boolean equation is correct, still give 0.

Ja = X

AB / X	00	01	11	10
0	0	0	*	*
1	1	1	*	*

Ka = ~B

AB / X	00	01	11	10
0	*	*	0	1
1	*	*	0	1

Jb = X

AB / X	00	01	11	10
0	0	*	*	0
1	1	*	*	1

Kb = ~A + X

AB / X	00	01	11	10
0	*	1	0	*
1	*	1	1	*

Q3-4. (2 pts) Determine and simplify a Boolean equation to represent the output Z.

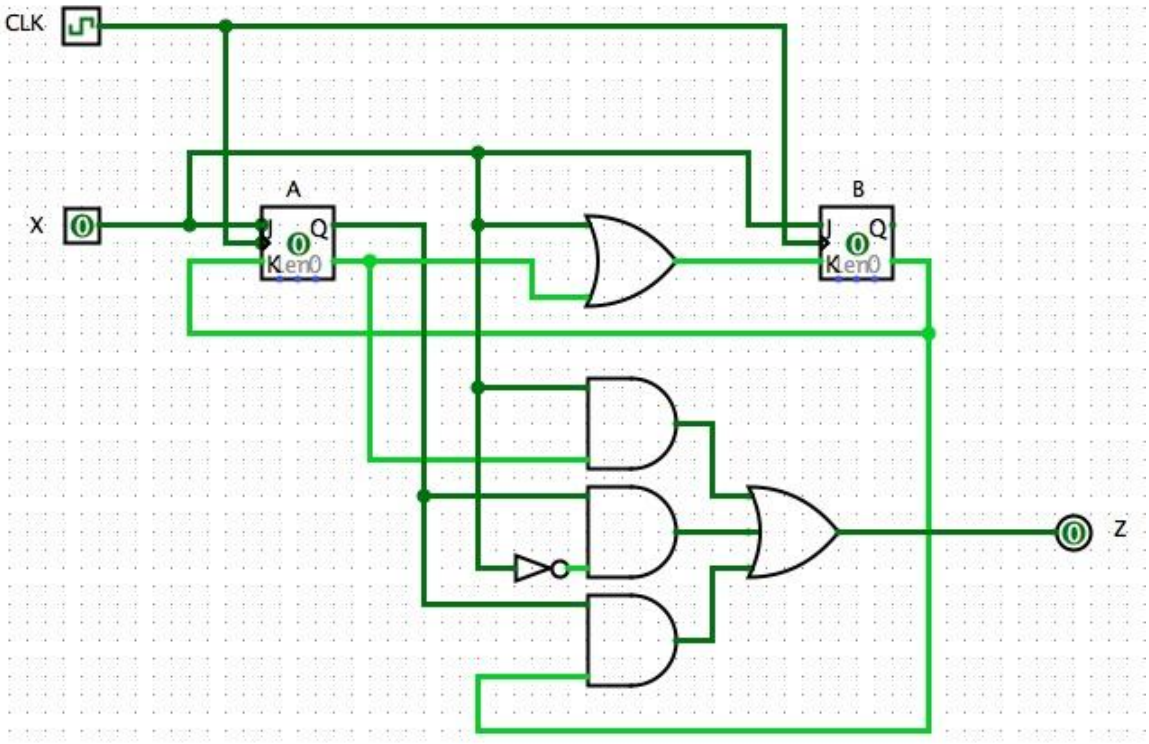
Grading guide: If the K-map is wrong but the Boolean equation is correct, still give 0.

Z = X~A + ~XA + A~B

AB / X	00	01	11	10
0	0	0	1	1
1	1	1	0	1

Q3-5. (2 pts) Draw the corresponding sequential circuit, using Logisim.
Capture the circuit image to your submission. No .circ file needed.

Grading guide: The circuit could look different. If the circuit picture is not included, -2.


CLK
X
A
B
Q
J
K
en
Z