5.17 Design a one-input, one-output serial 2's complementer. The circuit accepts a string of bits from the input and generates the 2's complement at the output. The circuit can be reset asynchronously to start and end the operation. (HDL—see Problem 5.39)

Solution → Suppose we have —

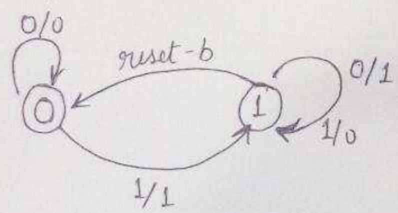
01001110101100

2's complement → 10110001010100

State table

Present state A	Input x	Next state $A(t+1)$	Output y
0	0	0	0
0	1	1	1
1	0	1	1
1	1	1	0

State Diagram



K-map for A(t+1)

$A \backslash x$	0	1
0	0	1
1	1	1

$$\boxed{A(t+1) = A+x}$$

$D_A = A+x$

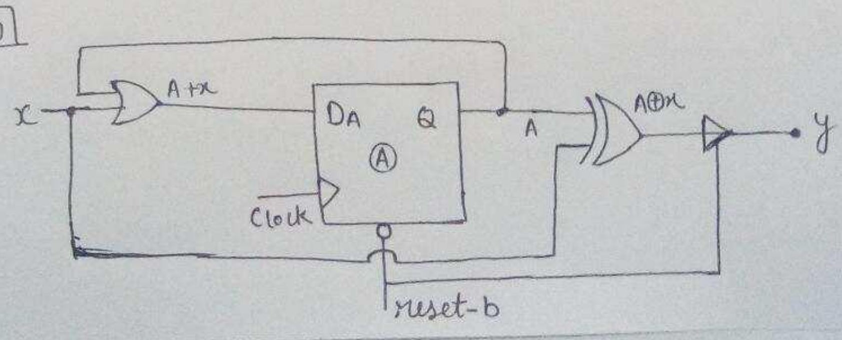
K-map for y

$A \backslash x$	0	1
0	0	1
1	1	0

$y = Ax' + A'x$

$$\boxed{y = A \oplus x}$$

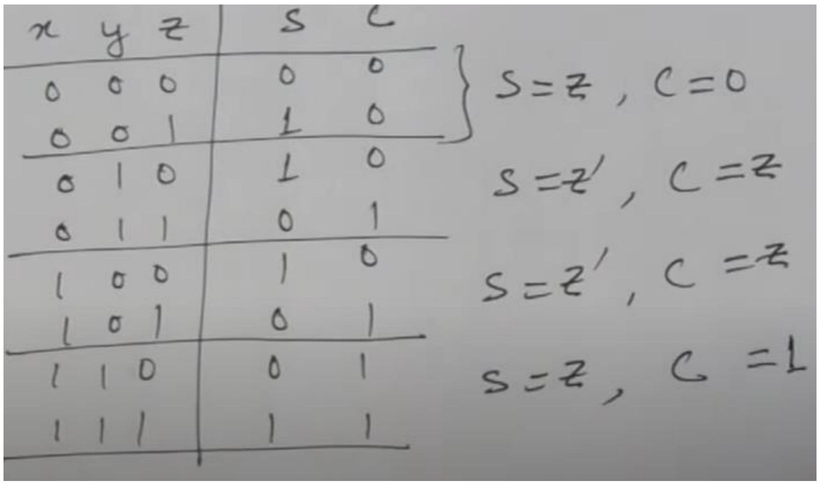
Design



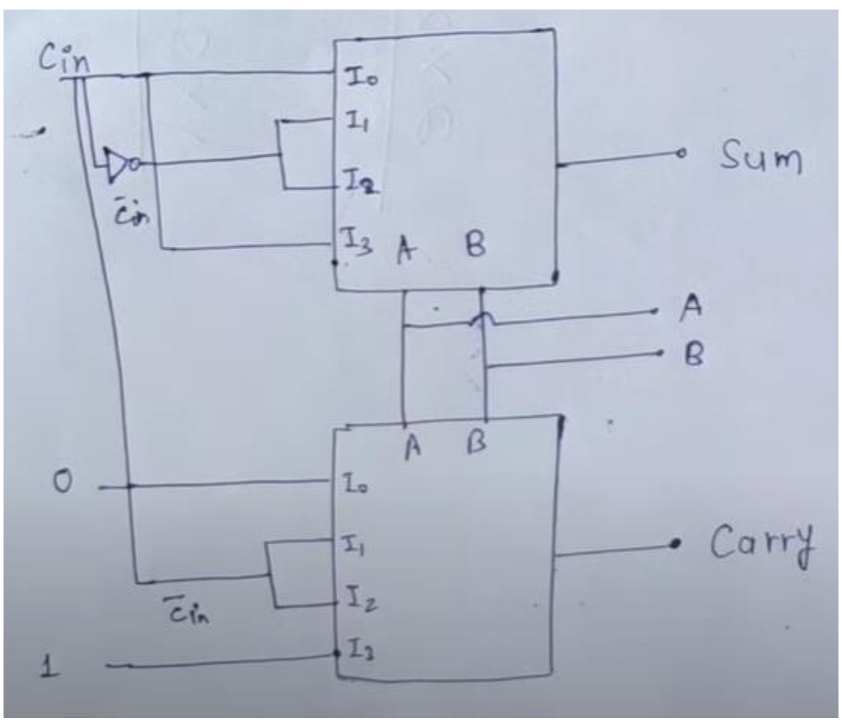
https://www.youtube.com/watch?v=aHgM51UaFmc

Question 2:

Where z = cin and x,y = A and B (inputs at select lines as shown in diagram)



x	y	z	S	C	
0	0	0	0	0	S = z , C = 0
0	0	1	1	0	
0	1	0	1	0	S = z' , C = z
0	1	1	0	1	
1	0	0	1	0	S = z' , C = z
1	0	1	0	1	
1	1	0	0	1	S = z , C = 1
1	1	1	1	1	



Question 3:

From the figure we can write that:

$J_A = A + B$ $\quad$ $K_A = x + A' + B'$

$T_B = A$ $\quad$ $y = (x + B + B')'$

State Equations

$A(t+1) = J_A A' + K_A' A = (A + B)A' + (x + A' + B')'A = A'B + x'AB$

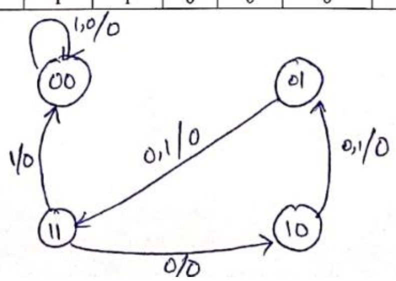
$B(t+1) = T_B \oplus B = A \oplus B$

$y = (x + B + B')' = (x + 1)' = 0$

State Table

Present State		Input			Next State		Output
A	B	x	A'B	x'AB	A(t + 1)	B(t + 1)	y
0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0
0	1	0	1	0	1	1	0
0	1	1	1	0	1	1	0
1	0	0	0	0	0	1	0
1	0	1	0	0	0	1	0
1	1	0	0	1	1	0	0
1	1	1	0	0	0	0	0

State Diagram



Question 4:

Part (i)

- F and H are equivalent, remove H and replace H with F.

After replacing H with F

- E and G are equivalent, remove G and replace G with E.
- C and D are equivalent, remove D and replace D with C.

After making the above replacements

- B and E are equivalent, remove E and replace E with B.

The reduced state table is

Present State	Next State		Output	
	$x = 0$	$x = 1$	$x = 0$	$x = 1$
A	A	B	1	0
B	C	F	0	1
C	B	F	1	0
F	F	B	1	1

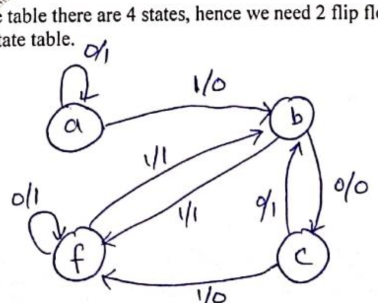
Part (ii)

As there are 8 states in the given table. So, we need 3 flip flops to design the circuit.

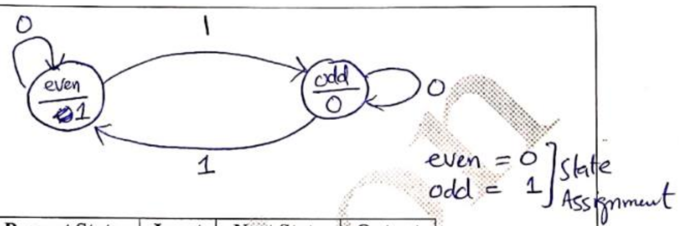
Part (iii)

In the reduced state table there are 4 states, hence we need 2 flip flops to design the circuit given by reduced state table.

Part (iv)



Question 5:



Present State	Input	Next State	Output
Q(t)	*x*	Q(t + 1)	Y
0	0	0	1
0	1	1	1
1	0	1	0
1	1	0	0

For a D flip flop Q(t + 1) = D, hence we need to find the equations of D and Y. From the table it can be clearly seen that:

$$D = Q \oplus X$$

$$Y = Q'$$

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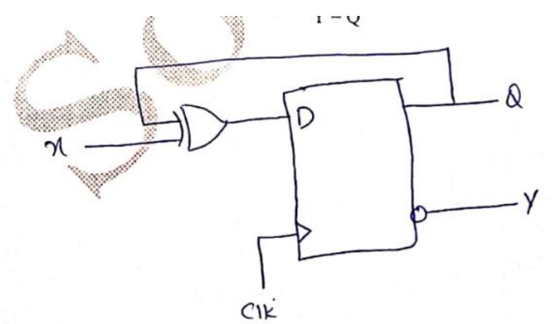

Question 6:

Question 1: Multiplexer (MUX)

What is the function of a 4-to-1 multiplexer? A) Combines four inputs into one output. B) Selects one of four inputs to output. C) Divides one input into four outputs. D) Encodes four inputs into fewer lines.

Answer: B) Selects one of four inputs to output.

Question 2: Decoders

What is true about a 2-to-4 line decoder? A) Activates multiple outputs at a time. B) Has 4 inputs and 2 outputs. C) Has 2 inputs and 4 outputs, one active at a time. D) All outputs are always active.

Answer: C) Has 2 inputs and 4 outputs, one active at a time.

Question 3: Latches

What does a D latch do? A) Divides the clock frequency. B) Stores a bit when enabled. C) Converts serial to parallel data. D) Toggles between states.

Answer: B) Stores a bit when enabled.

Question 4: Sequential Circuits

What feature do sequential circuits have? A) Only arithmetic operations. B) Memory elements. C) No clock signals. D) Faster than combinational circuits.

Answer: B) Memory elements.

Question 5: Decoders and MUX

How can decoders and multiplexers be used together? A) Decoder enables multiplexer signals. B) Multiplexer selects decoders. C) Decoder outputs connect to multiplexer inputs. D) Multiplexer generates decoder selection lines.

Answer: A) Decoder enables multiplexer signals.

BONUS:

The answer to this riddle lies in the way the apples are taken from the basket. Here's how it could work:

1. You take an apple, leaving **four** in the basket.
2. Your friend takes an apple, leaving **three** in the basket.
3. Their friend takes the last apple, but they take it **along with the basket**.

So, the friend took both an apple and the basket, which still had one apple in it. Therefore, one apple remains in the basket. It's a clever play on words!