Lecture # 12

Counters

\#

$$=) \qquad \text{⅃} \quad \leadsto \quad Q_{n+1} = D$$

Otherwise $\leadsto Q_{n+1} = Q_n$

\#
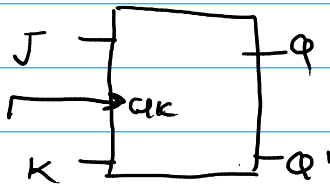
J	K	Q_{n+1}
0	0	No Change
0	1	0
1	0	1
1	1	$\overline{Q_n}$

\#
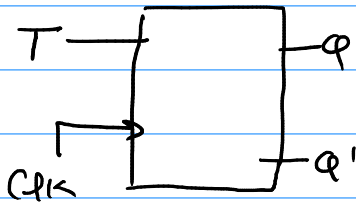
T	Q_{n+1}
0	Q_n
1	$\overline{Q_n}$

Register

7 6 5 4 3 2 1 0
1 1 0 1 1 0 1 1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_8

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_8
1	1	0	1	1	0	1	1

| 0 | U | 0 | 0 |

$\downarrow$

1 , 0 , 0 , ① , 0

0 0 0 ϕ

Q_D D_D — Q_C D_C — Q_B D_B — Q_A D_A A

Clk

| 0 | 0 | 0 | 1 | 0   after   1 clk pulse. edge ↑

↑

| 0 | 0 | 1 | 0 | ∿ 1   2nd clk edge ⊓⌐↲

| 0 | 1 | 0 | 1 | → 3rd clk ↑

| 1 | 0 | 1 | 0 | → 4th clk ↲

	1		0		1		0
D Q 1		D Q 0		D Q 1		D Q 0	

f_{Clk}

Clk

Q_A Q_B Q_C

1 → 0 → 0 → 1

1 → 1 → 0 → 0

2 → 0 → 1 → 0

3 → 0   0   1

0 0 1
1 0 0
0 1 0
0 0 1

Q T

f_{Clk}

Q_A 1   0   0   0   0   0

Q_B 0   1   0   0   1   0
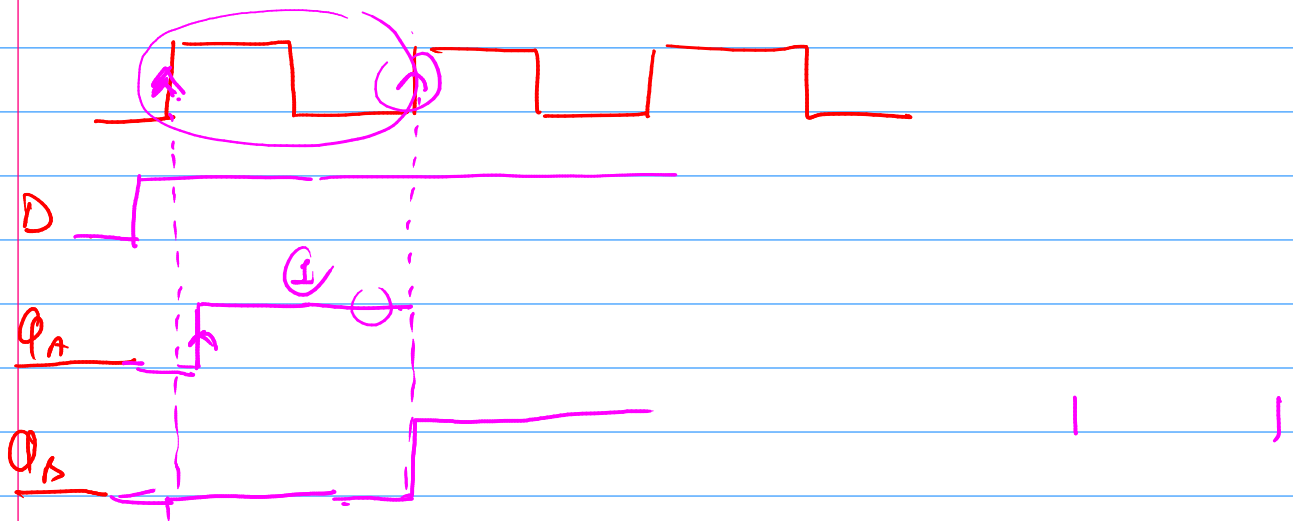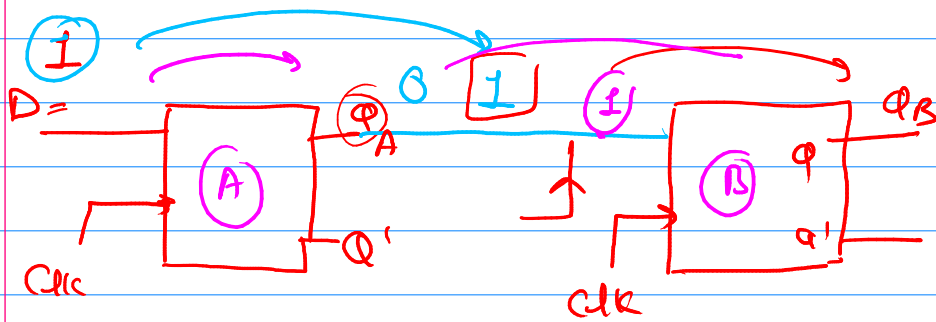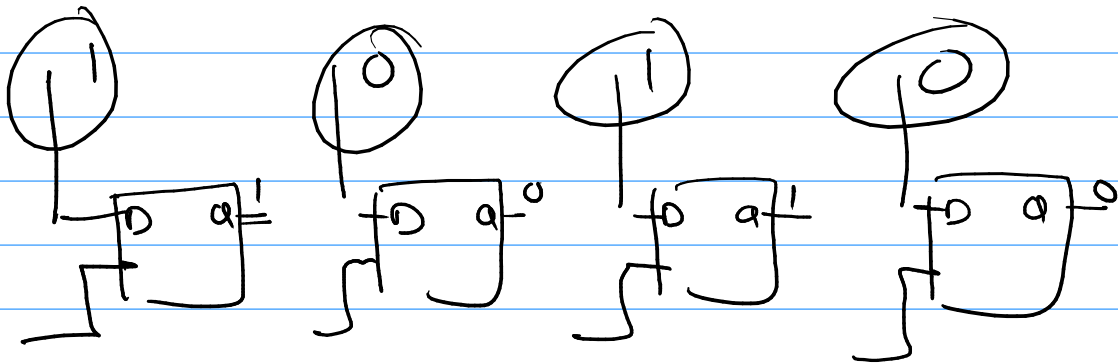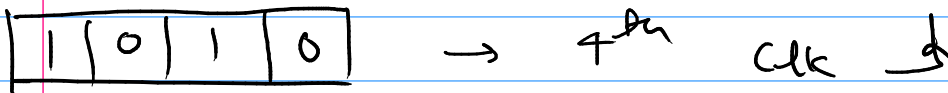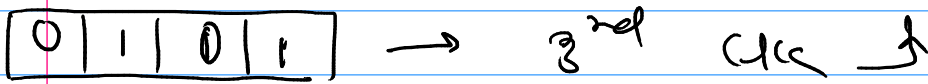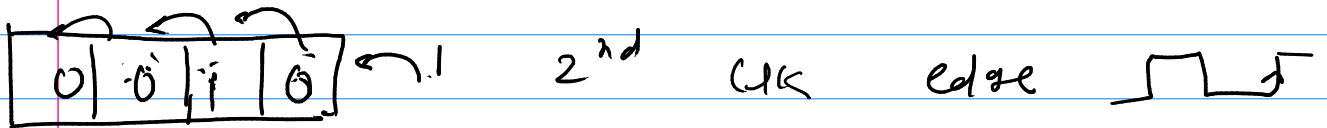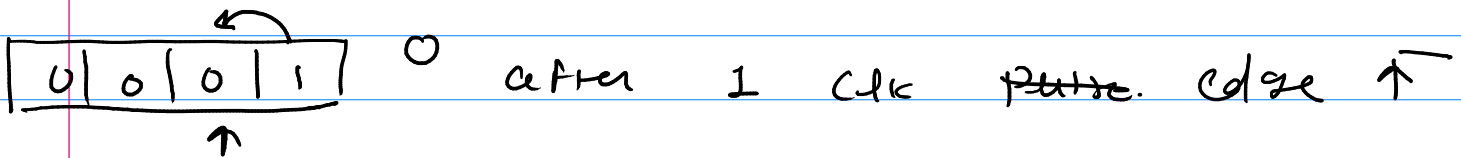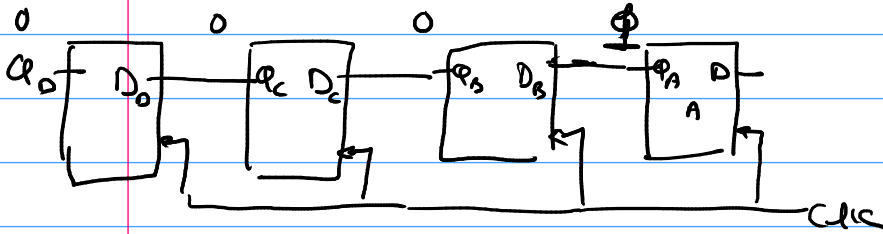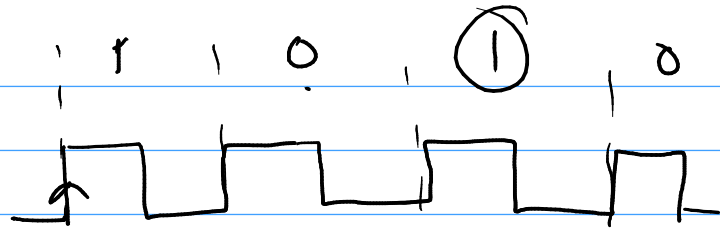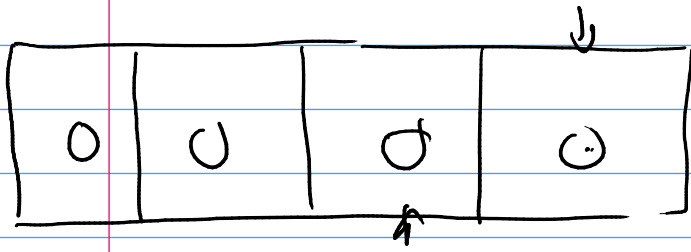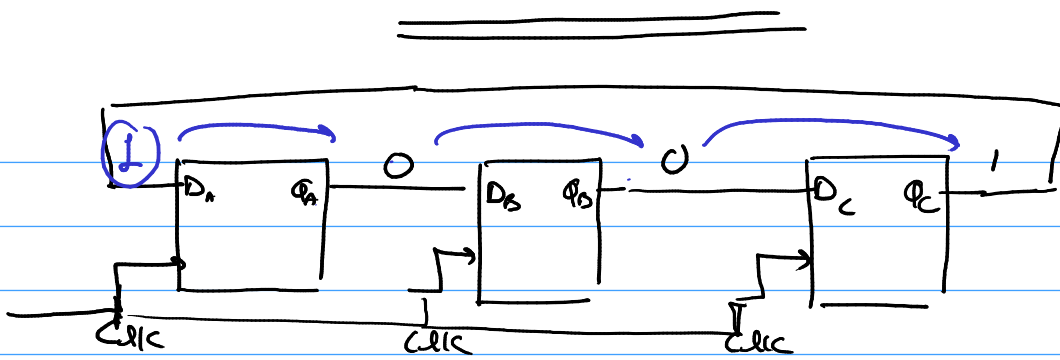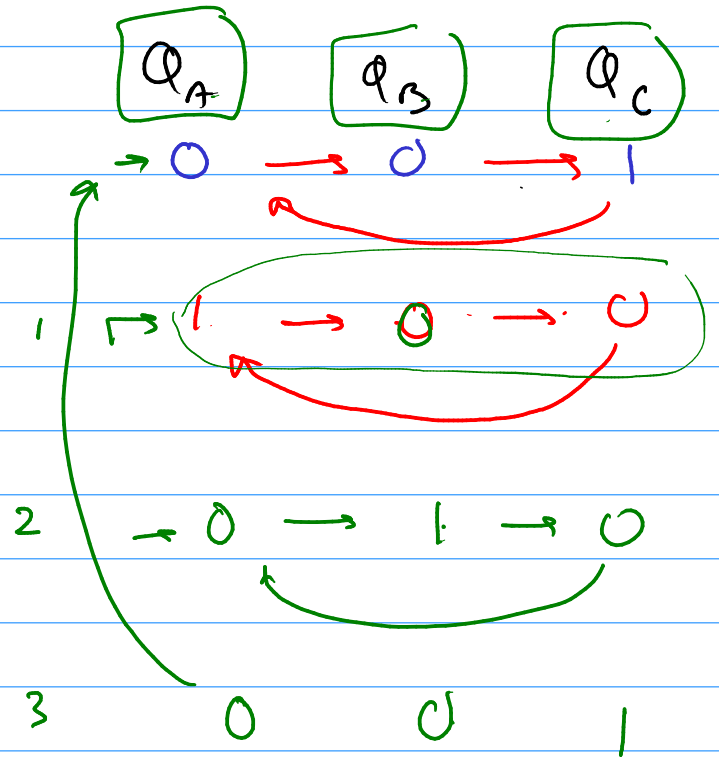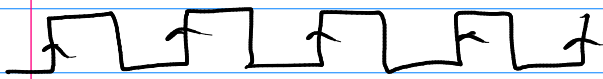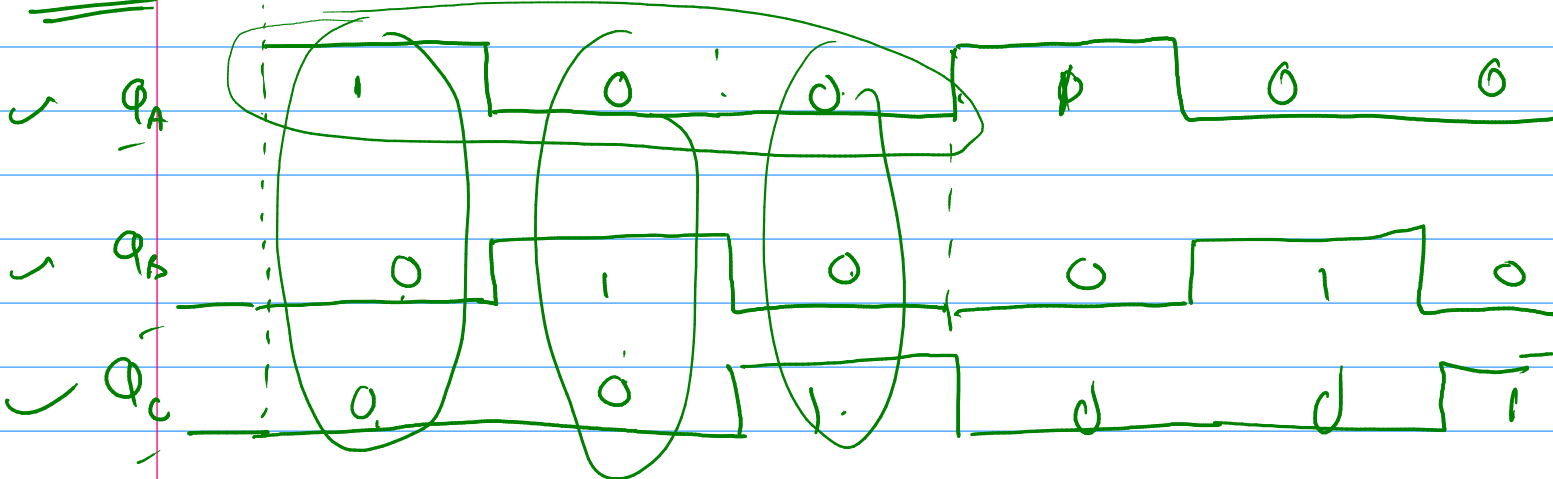
Q_C 0   0   1   0   0   1

Ring Counter
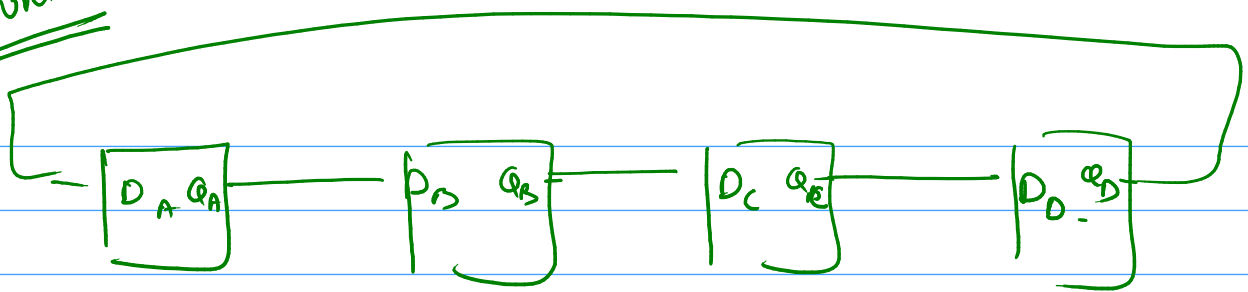
1	0	0	0
0	1	0	0
0	0	1	0
0	0	0	1
1	0	0	0

Johnson counter
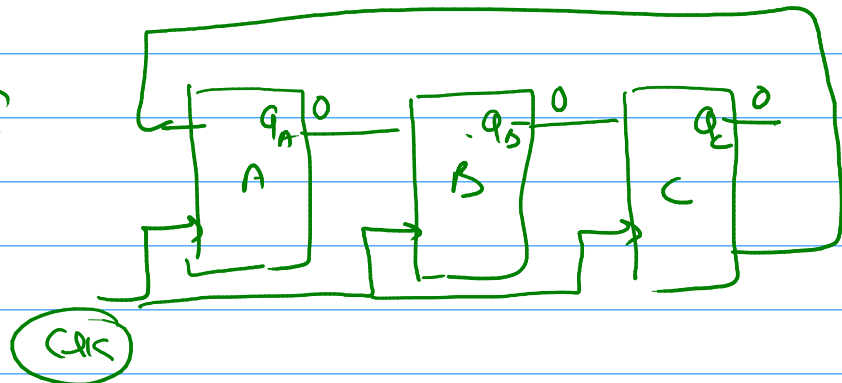
Q_A	Q_B	Q_C
0	0	0
1	0	0
1	1	0
1	1	1
0	1	1
0	0	1
0	0	0

$$f_{Q_\pi} = \frac{f_{CLK}}{6} \implies \underline{50\%} $$
$$\text{Duty cycle}$$

$$n \to \quad \frac{f_{CLK}}{2n}$$

φ_A 0 1 1 1 0 0 0 1 1 1 0 0

φ_B 0 0 1 1 1 0 0

φ_C 0 0 0 1 1 1 0

0 0 0 0

1 → 0 → 0 → 0

1 1 0 0

1 1 1 0

1 1 1 1
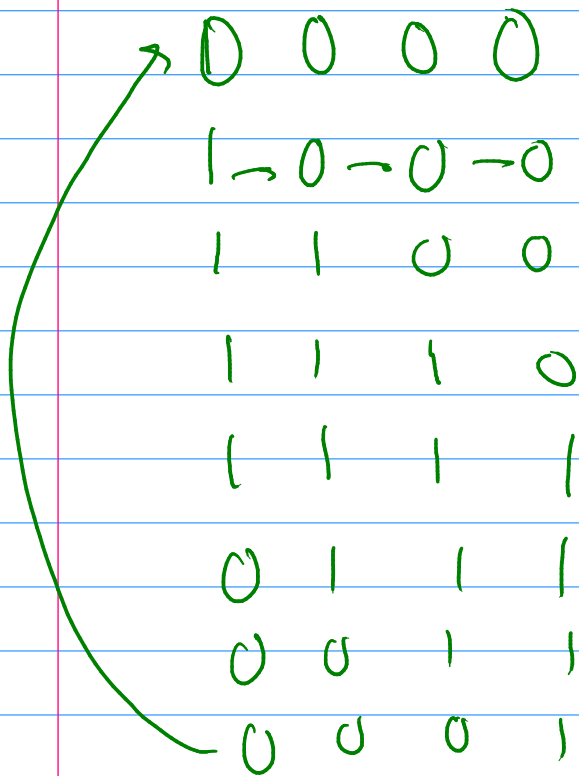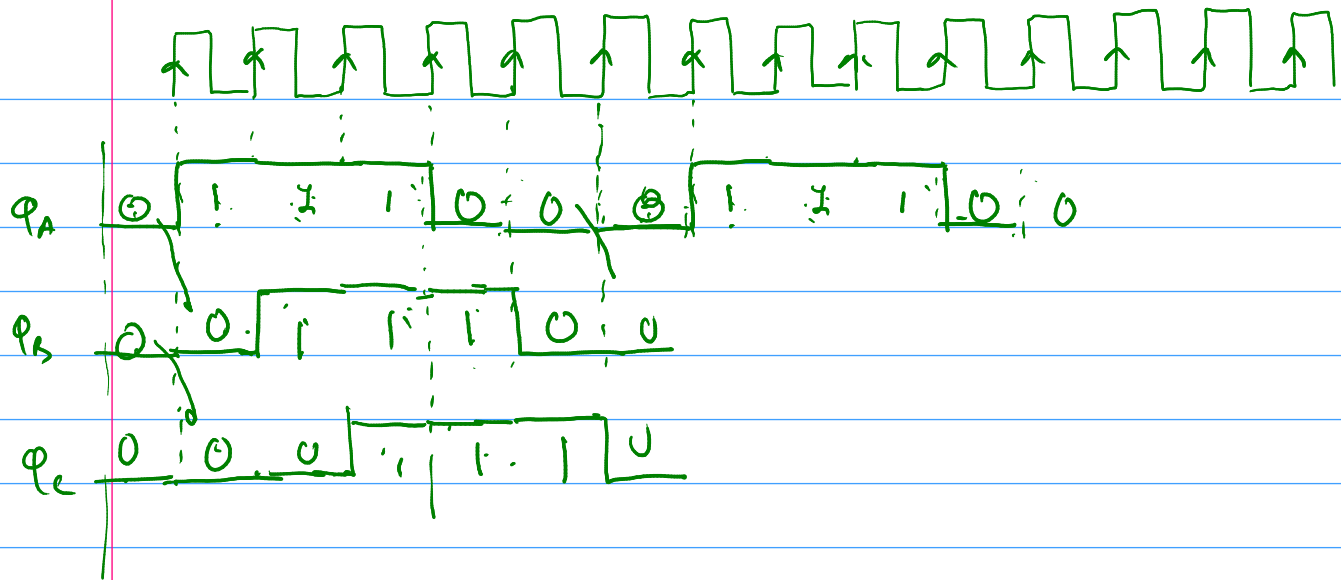
0 1 1 1

0 0 1 1

0 0 0 1

50 %

ASYNCH
Blocks

001 ~ 1
100 → 4
010 → 2
001 ~ 1

CLK

φ_A 0 1   0   1   0   1

φ_B 0 1   1   0   0   1

φ_B	φ_A		
1	1	→	3
1	0	→	2
0	1	→	1
0	0	→	0
1	1	→	3

Circuit: T flip-flop A with input 1, T_A, outputs Φ_A (O), Φ_A', clock CLK. T flip-flop B with input 1, T_B, outputs Φ_B (O), Φ_B', clock input from A.

CLK

Timing diagram with rising-edge arrows.

Φ_A: 0 1 0 1 0

Φ_B: 0 0 1 1 0

Φ_B	Φ_A
0	0
0	1
1	0
1	1
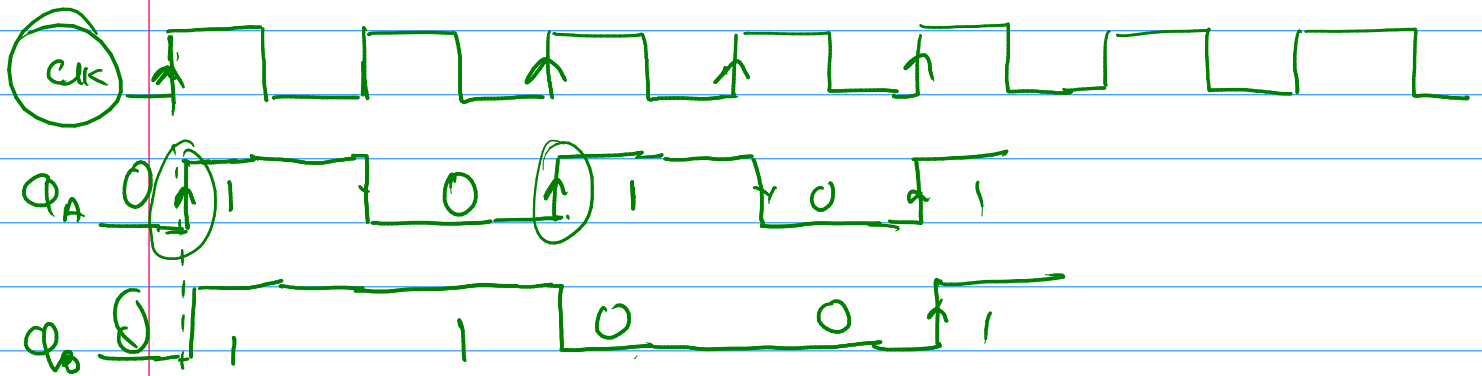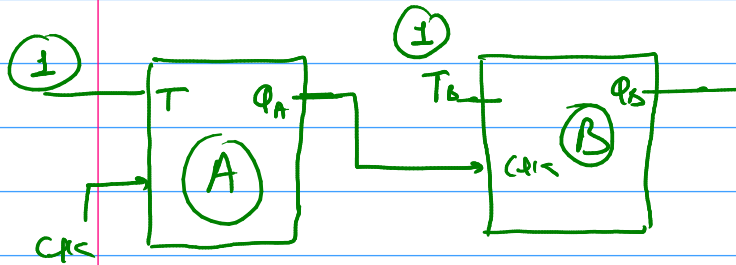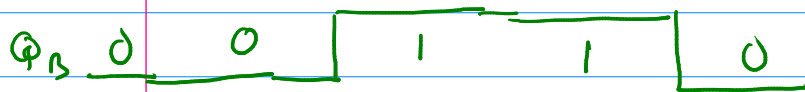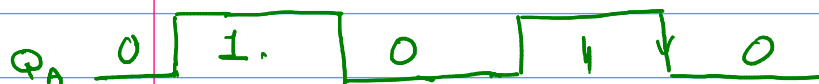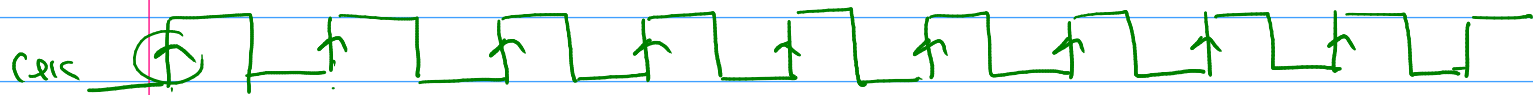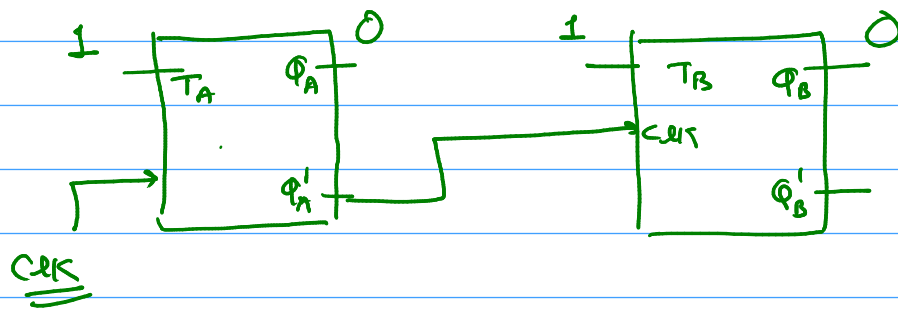
Φ_C	Φ_B	Φ_A	
0	0	0	↑
0	0	1	↑
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

$$\Phi_A = \frac{f_{CLK}}{2}$$

$$\Phi_B = \frac{f_{CLK}}{4}$$

$$\Phi_C = \frac{f_{CLK}}{8}$$

0　　1　　2　　3　　4　　5　　6　　7

8　　9　　0

I — T_A Q_A — T_B Q_B — T_C Q_C — T_D Q_D

Clk → Clk — Clk — Clk — Clk
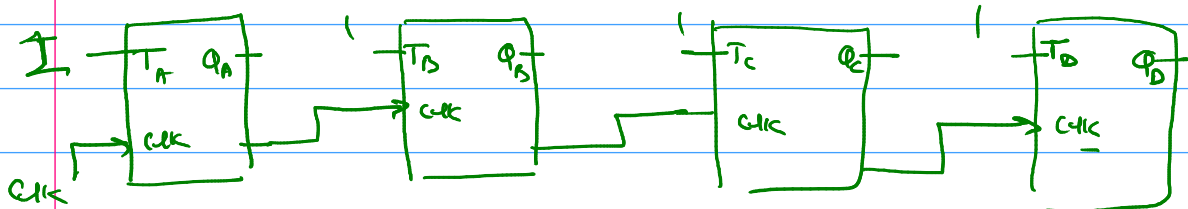
Q_D Q_C Q_B Q_A

1　0　1　0

$$Q_A' \cdot Q_B \cdot Q_C' \cdot Q_D = \underline{RST}$$

\#

always (Clk , ~~RST~~)

if (RST == 1)

then Q = 0

Else

if (T == 1)

then Q = ~~Q~~.

End ;