## QUESTION 1

a) $T_0 = A + B$ $\quad \left\{ Q_0^+ = T_0 \oplus Q_0 \right.$

$D_1 = Q_0 A$ $\quad \left. Q_1^+ = D_1 \right.$

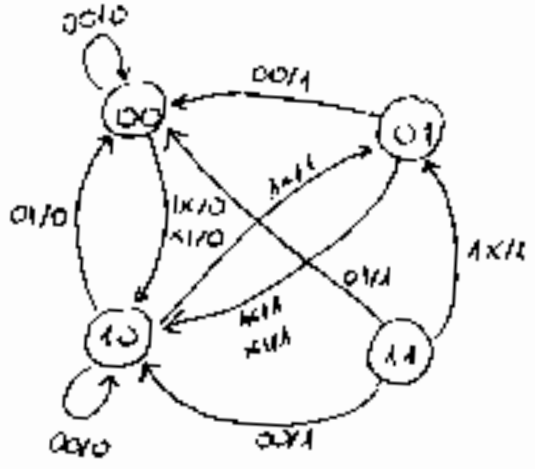
b) $S = Q_0 A + Q_1$

c) Mealy's, as $S$ is a function that depends on the input

$S = f(\underline{A}, Q_0, Q_1)$

d)

| A | B | $Q_0$ | $Q_1$ | $Q_0^+$ | $Q_1^+$ | S |
|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 | 1 |



## QUESTION 2

a) 1 — A input
   1 — B output

b) 1

| state | $Q_1$ $Q_0$ |
|---|---|
| $E_0$ | 0 0 |
| reset → $E_1$ | 0 1 |
| $E_2$ | 1 0 |

2 Flip-Flops to encode 3 states ($2^2 > 3$)

c) 3

| $Q_1$ $Q_0$ A | $D_1^+$ $Q_0^+$ | B | $T_1$ $T_0$ |
|---|---|---|---|
| 0 0 0 | 0 0 | 0 | 0 0 |
| 0 0 1 | 0 1 | 1 | 0 1 |
| 0 1 0 | 1 0 | 0 | 1 1 |
| 0 1 1 | 0 0 | 1 | 0 1 |
| 1 0 0 | 0 1 | 0 | 1 1 |
| 1 0 1 | 0 0 | 0 | 1 0 |
| 1 1 0 | x x | x | x x |
| 1 1 1 | x x | x | x x |

d) 3

| $Q_1/Q_0$ A | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | x | x |

$B = Q_1 A$

| $Q_1/Q_0$ A | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 1 | 1 | 1 | x | x |

$T_1 = Q_1 + Q_0 \bar{A}$

| $Q_1/Q_0$ A | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 1 | 1 |
| 1 | 1 | 0 | x | x |

$T_0 = Q_0 + Q_1 \bar{A} + Q_1 A = Q_0 + (Q_1 \oplus A)$

$T_0 = (Q_1 + Q_0 + A)(\bar{Q_1} + \bar{A})$

Note with D Flip-Flops (considered as correct in the corrections)

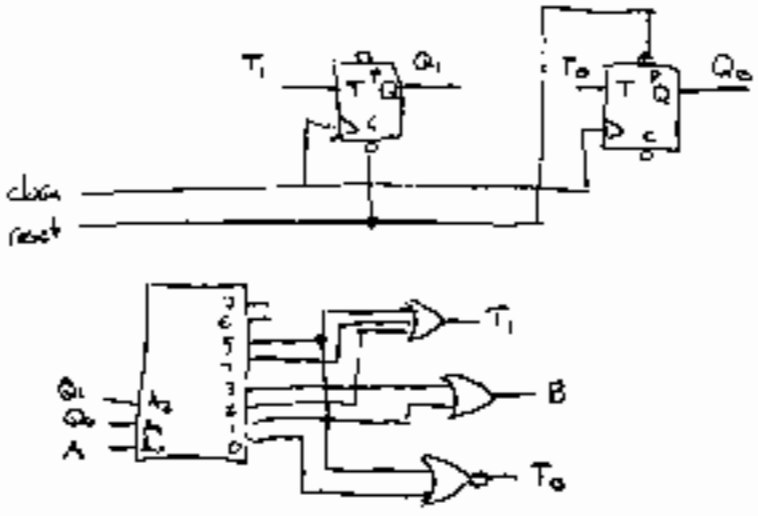
| $Q_1/Q_0$ A | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | x | x |

$D_1 = Q_1^+ = Q_0 \bar{A}$

| $Q_1/Q_0$ A | 00 | 01 | 11 | 10 |
|---|---|---|---|---|
| 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | x | x |

$D_0 = Q_0^+ = \bar{Q_1} Q_0 A + Q_1 \bar{A}$

d)



Universidad Carlos III de Madrid

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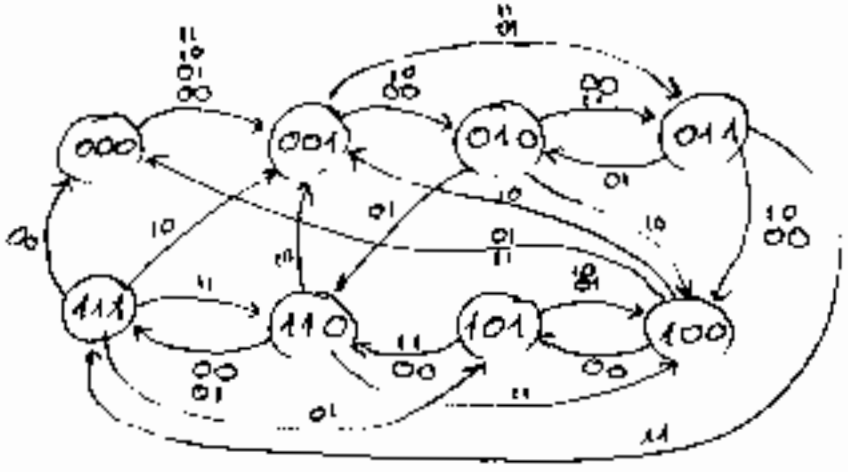
## Question 3

We want to design a sequential circuit which can remotely control the operation of the door of a garage. In order to operate the door of garage, the remote controller sends one of the following cyclic sequences depending on the selection of the switches S0 and S1.

| S1 | S0 | Sequence: |
|---|---|---|
| 0 | 0 | 3-bit binary counter (natural binary code) |
| 0 | 1 | 3-bit Gray's code counter |
| 1 | 0 | 3-bit Ring counter |
| 1 | 1 | 3-bit Johnson's code |

Then, draw the state transition graph of a finite state machine using Moore's model for the above described remote control operation.

outputs = state = $Q_2 Q_1 Q_0$




Gray's code:

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

Ring counter:

0 0 1
0 1 0
1 0 0

Johnson's code

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