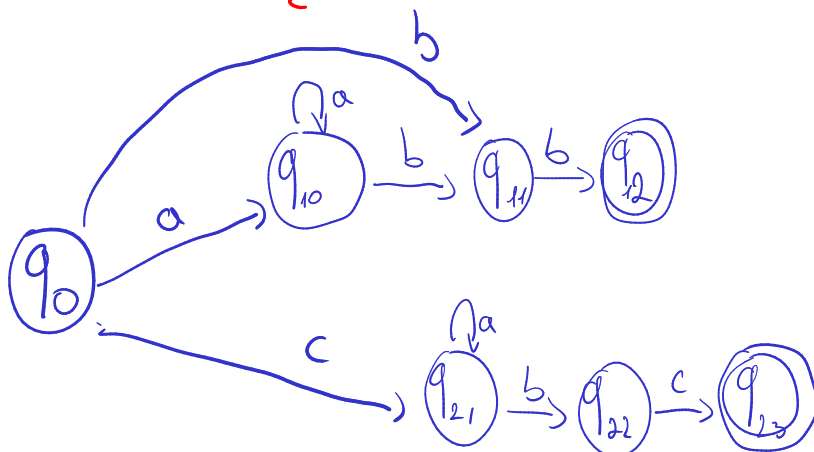
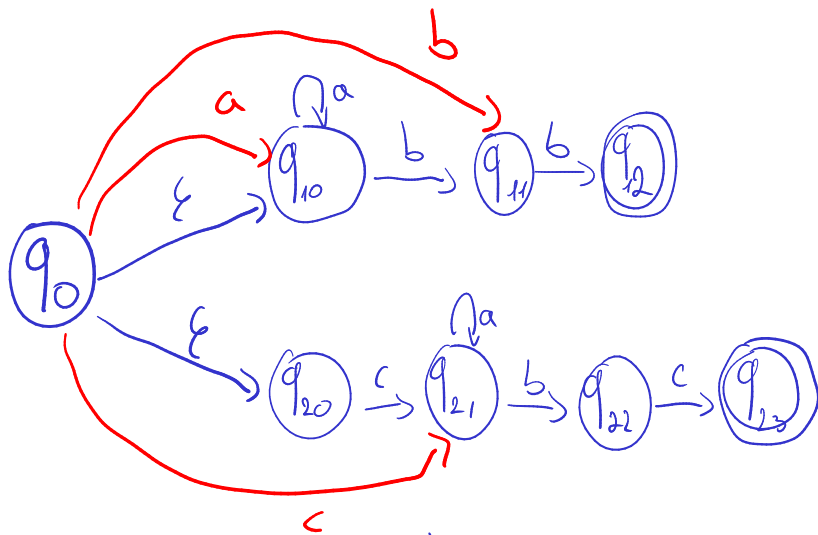
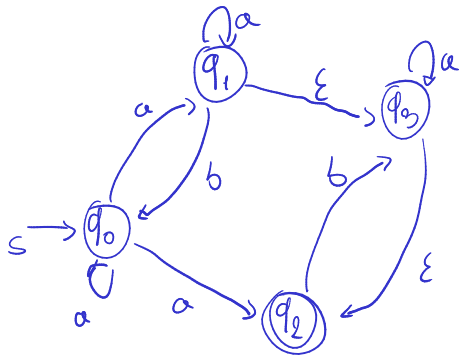


$$\delta(q_0, \epsilon) = q_1, q_0 \quad \delta(q_0, \epsilon) = \delta(q_1, a) = q_0$$

$$\delta(q_1, a) = q_0$$

$$L = \underbrace{a^*bb}_{A_1} + \underbrace{ca^*b}_{A_2}$$





$$\epsilon\text{-closure}(q_0) = \{q_0\}$$

$$\epsilon\text{-closure}(q_1) = \{q_1, q_2, q_3\}$$

$$\epsilon\text{-closure}(q_2) = \{q_2\}$$

$$\epsilon\text{-closure}(q_3) = \{q_2, q_3\}$$

ϵ -NFA

	a	b	ϵ
0	0,1,2	\emptyset	0
1	1	0	1,2,3
2	\emptyset	3	2
3	3	\emptyset	2,3

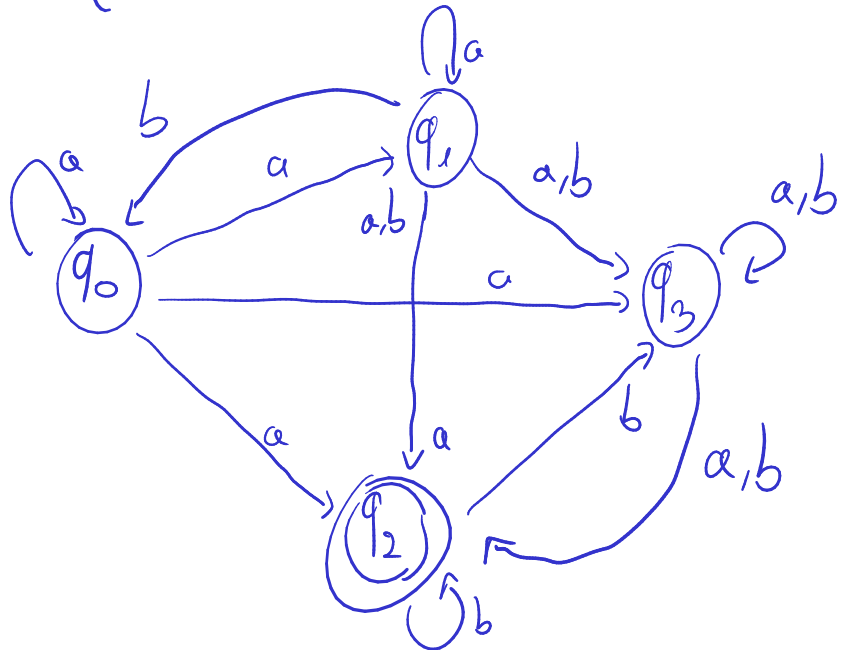
NFA	a	b
0	0,1,2,3	\emptyset
1	1,2,3	0,2,3
2	\emptyset	2,3
3	2,3	2,3

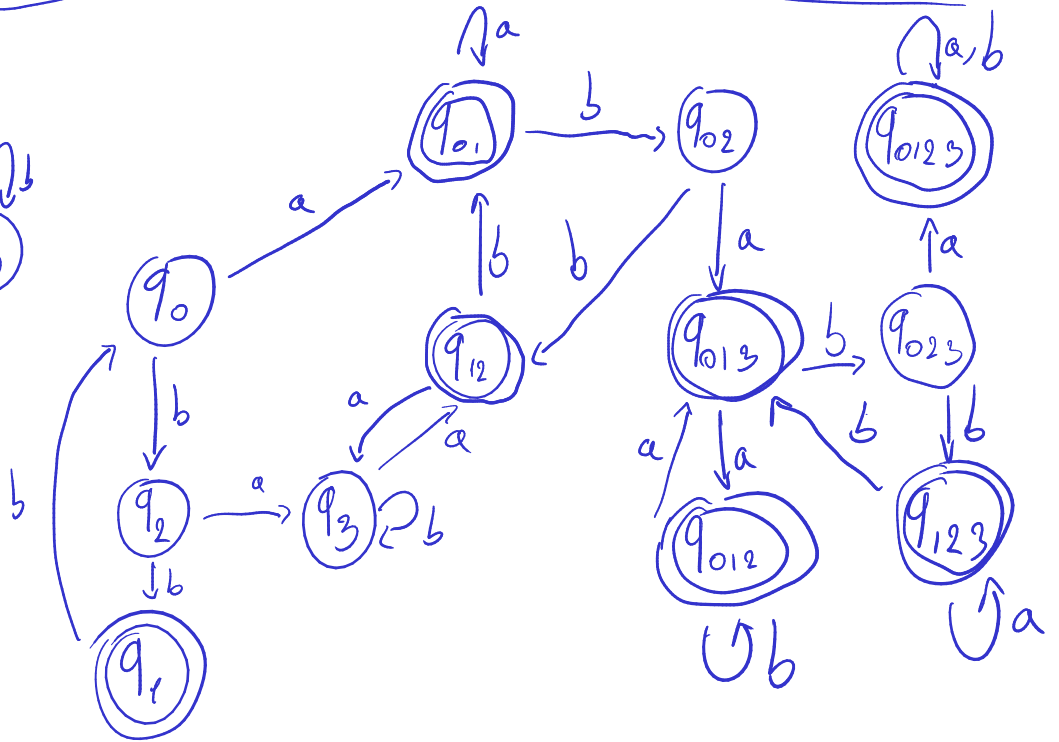
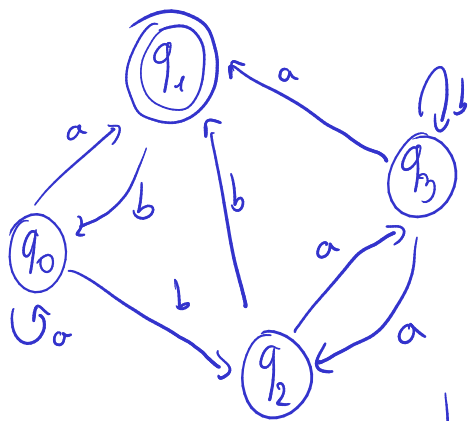
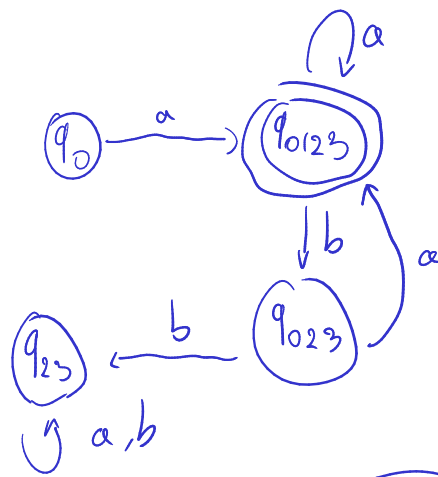
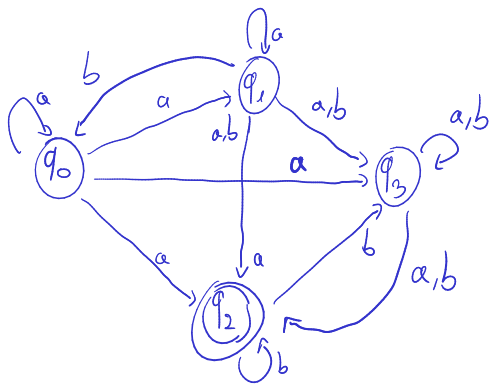
$$\delta'(q_0, a) = \epsilon\text{-closure}(\delta(\epsilon\text{-closure}(q_0), a))$$

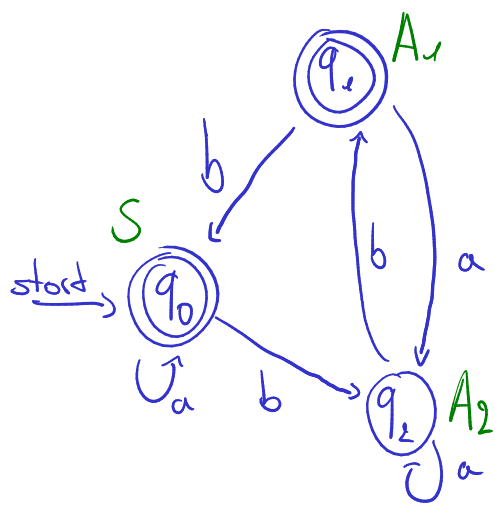
$$= \epsilon\text{-closure}(\delta(q_0, a))$$

$$= \epsilon\text{-closure}(0, 1, 2) =$$

NFA	a	b
$\rightarrow 0$	0,1,2,3	\emptyset
1	1,2,3	0,2,3
2	\emptyset	2,3
3	2,3	2,3







$$S \rightarrow aS \mid bA_2 \mid a$$

$$A_1 \rightarrow bS \mid aA_2 \mid a$$

$$A_2 \rightarrow aA_2 \mid bA_1 \mid b$$

\parallel

$$\begin{cases} S = aS + bA_2 + a \\ A_1 = bS + aA_2 + a \Rightarrow \\ A_2 = aA_2 + bA_1 + b \end{cases}$$

$$\Rightarrow A_2 = a^*(bA_1 + b)$$

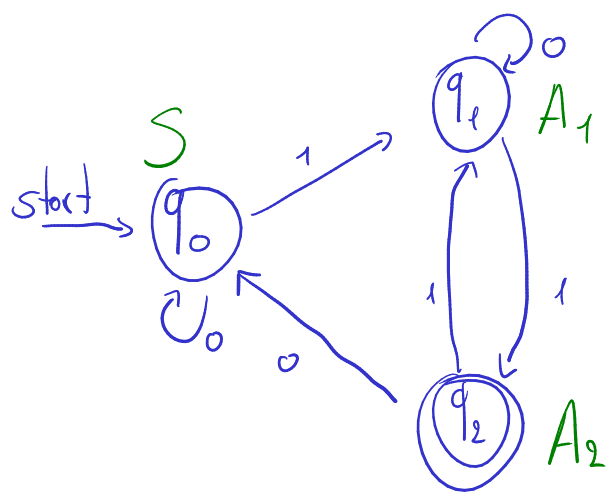
$$A_1 = bS + aa^*(bA_1 + b) + a$$

$$A_1 = (a^+b)^*(bS + a^+b + a) \xRightarrow{A_2} A_2 = a^*(b(a^+b)^*(bS + a^+b + a) + b)$$

$$(a^+b)^*a^+b = (a^+b)^+ = a^*(b(a^+b)^*bS + \underline{b(a^+b)^*a^+b} + b(a^+b)^*a + b)$$

$$S = aS + ba^*[b(a^+b)^*bS + (a^+b)^+ + b(a^+b)^*a + b]$$

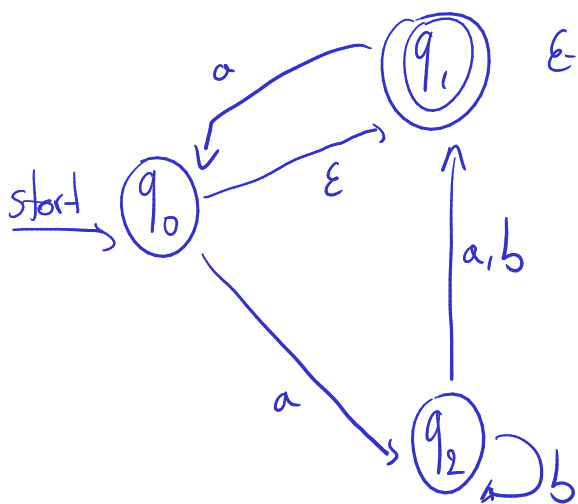
$$= (a + ba^*b(a^+b)^*b)^* \left\{ ba^*[(a^+b)^+ + b(a^+b)^*a + b] \right\} + a$$



$$\begin{aligned}
 S &\rightarrow 0S \mid 1A_1 \\
 A_1 &\rightarrow 0A_1 \mid 1A_2 \mid 1 \\
 A_2 &\rightarrow 0S \mid 1A_1 \\
 &\Downarrow
 \end{aligned}$$

$$\begin{cases} S = 0S + 1A_1 \\ A_1 = 0A_1 + 1A_2 + 1 \\ A_2 = 0S + 1A_1 \end{cases} \Rightarrow \begin{cases} S = A_2 \\ S = 0S + 1A_1 \\ A_1 = 0A_1 + 1S + 1 \end{cases}$$

$$\Rightarrow \begin{cases} S = 0S + 10^*(1S+1) \\ A_1 = 0^*(1S+1) \end{cases} \Rightarrow S = (0 + 10^*1)^* 10^*1$$



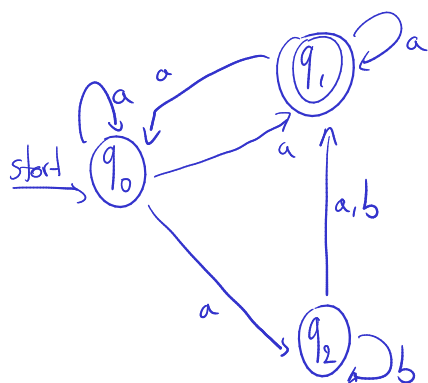
$$\epsilon\text{-NFA}$$

	a	b	ϵ
q_0	q_2	\emptyset	q_1
q_1	q_0	\emptyset	\emptyset
q_2	q_1	q_1, q_2	\emptyset

$$\epsilon\text{-cl}(q_0) = \{q_0, q_1\}$$

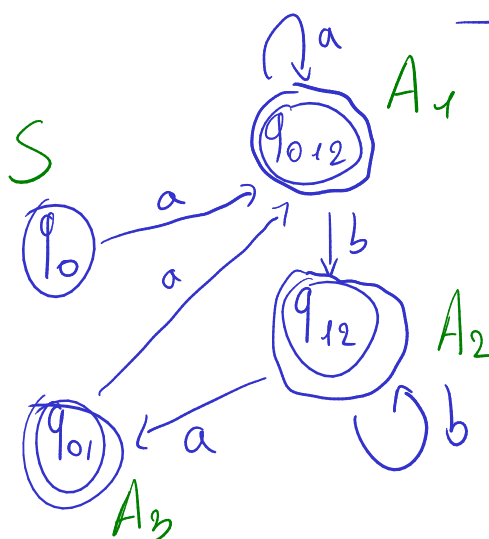
$$\epsilon\text{-cl}(q_1) = \{q_1\}$$

$$\epsilon\text{-cl}(q_2) = \{q_2\}$$



$$\text{NFA}$$

	a	b
q_0	q_0, q_1, q_2	\emptyset
q_1	q_0, q_1	\emptyset
q_2	q_1	q_1, q_2



$$S \rightarrow aA_1 \mid a$$

$$A_1 \rightarrow aA_1 \mid bA_2 \mid a \mid b$$

$$A_2 \rightarrow bA_2 \mid aA_3 \mid a \mid b$$

~~$$A_3 \rightarrow aA_1 \mid a$$~~

$$S = A_3$$

$$\begin{cases} S = aA_1 + a \\ \Rightarrow A_1 = aA_1 + bA_2 + a + b \\ A_2 = bA_2 + aS + a + b \end{cases}$$

$$bb^*(aS + a + b) = b^+(aS + a + b)$$

$$A_2 = b^+(aS + a + b)$$

$$A_1 = \underbrace{aA_1}_{a^+} + b^+(aS + a + b) + a + b = a^*(b^+(aS + a + b) + a + b)$$

$$A_1 = a^*b^+(aS + a + b) + \underbrace{a^+}_{a^+} + a^*b$$

$$\begin{aligned}
 S &= a \left[a^* b^+ (aS + a + b) + a^+ + a^* b \right] + a \\
 &= a^+ b^+ (aS + a + b) + a a^+ + a a^* b + a \\
 &\quad \quad \quad \textcolor{red}{a^+ b} \\
 &= (a^+ b^+ a)^* (a^+ b^+ a + a^+ b^+ b + a a^+ + a^+ b + a)
 \end{aligned}$$

	q_1	q_2	q_3	q_4	q_5	q_6	q_7	q_8
a	q_1	q_3	q_4	q_3	q_4	q_6	q_2	q_3
b	q_4	q_1	q_2	q_5	q_6	q_3	q_4	q_1

$$F = \{q_3, q_4\}$$

q_2	X						
q_3	X	X					
q_4	X	X					
q_5	X		X	X			
q_6		X	X	X	X		
q_7	X	X	X	X	X	X	
q_8	X		X	X		X	X
	q_1	q_2	q_3	q_4	q_5	q_6	q_7

	2,1	3,4	1,5	2,5	1,6	2,6	5,6	1,7	2,7	5,7	6,7
a	1,3	3,4	1,4	3,4	1,6	3,6	4,6	1,2	3,2	4,2	6,2
b	4,1	2,5	4,6	1,6	4,3	1,3	6,3	4,4	1,4	6,4	3,4

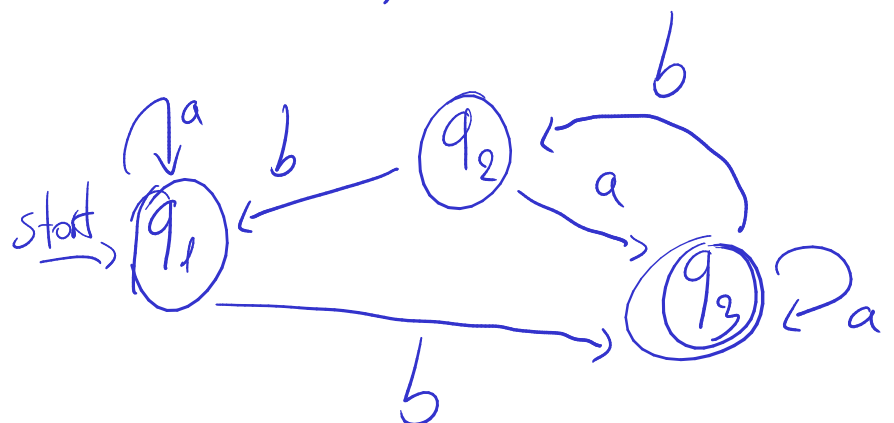
	1,8	2,8	5,8	6,8	7,8
a	1,3	3,3	4,3	3,6	2,3
b	4,1	1,1	6,1	3,1	4,1

$$(q_4, q_3), (q_2, q_5), (q_1, 6), (q_2, q_3), (q_5, q_8)$$

$$q_2 \equiv q_5 \equiv q_8 \Rightarrow q_2$$

$$q_1 \equiv q_6 \Rightarrow q_1: \text{start}$$

$$q_3 \equiv q_4 \Rightarrow q_3 \in F$$



	S	A
	q_0	q_1
0	q_0	$\{q_0, q_1\}$
1	q_1	q_0

$q_1 \in F$

$$S \rightarrow 0S \mid 1A \mid 1$$

$$A \rightarrow 0A \mid 0S \mid 1S \mid 0$$

\Downarrow

$$\begin{cases} S = 0S + 1A + 1 \\ A = 0A + 0S + 1S + 0 \end{cases} \triangleq$$

$$\Rightarrow \begin{cases} S = 0S + 10^*(0S + 1S + 0) + 1 = \underbrace{(0 + 10^+ + 10^*1)^+}_{\text{green}} (10^+ + 1) = S \\ A = 0^*(0S + 1S + 0) \end{cases}$$

	q_0	q_1	q_2	q_3	q_4	q_5
a	q_1	q_4	q_5	q_4	q_0	q_5
b	q_2	q_3	q_3	q_4	q_1	q_5

$$F = \{q_4, q_5\}$$

q_1	X				
q_2	X				
q_3	X	X	X		
q_4	X	X	X	X	
q_5	X	X	X	X	(1,2)
	q_0	q_1	q_2	q_3	q_4

	0,1	0,2	1,2	2,3	1,3	2,3	4,5
a	1,4	1,5	4,5	1,4	4,1	5,4	0,5
b	2,3	2,3	3,3	2,4	3,4	3,4	1,5