17/07/23

Problem → Algorithm

↓

Coding

TOC (To check whether Problem is solvable)

Finite $\boxed{\text{Automata} \rightarrow \text{(Machine)}}$

Push down Automata

Turning Machine

Language

1) Symbols 'a' 'x' 'y' '△'

Alphabet → set of symbols in a language a, b $\Sigma = \{a, b\}$

2) string → word or group of symbols

3) Language → All the words put together is a language.

L is a language

L = { string only start with a }

L = {a, aa, ab, aaa, aab, aba, aaaa ... }

ba

string not acceptable by this language

$L = \{$set of strings having length 2$\}$

$L = \{aa, ab, ba, bb\}$

$L = \{$string having length 3$\}$

$L = \{aaa, aab, aba, abb,$
$baa, bab, bba,$
$bbb\}$

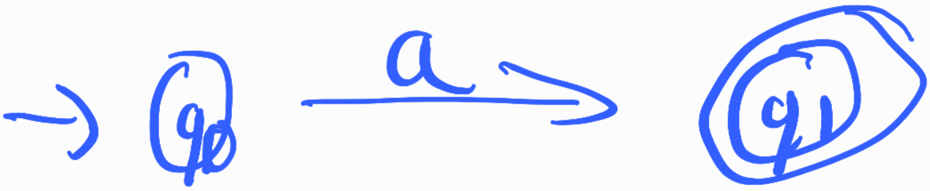
If the machine stops at the final state then the word or string is acceptable

$L = \{$string start with a$\}$

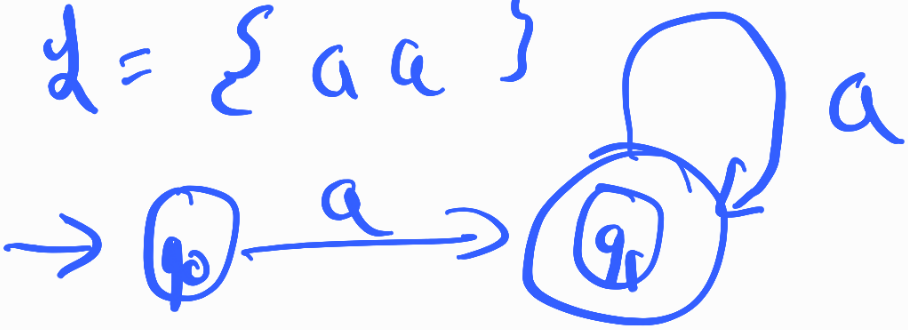
Initial state

final state

$L = \{a\}$

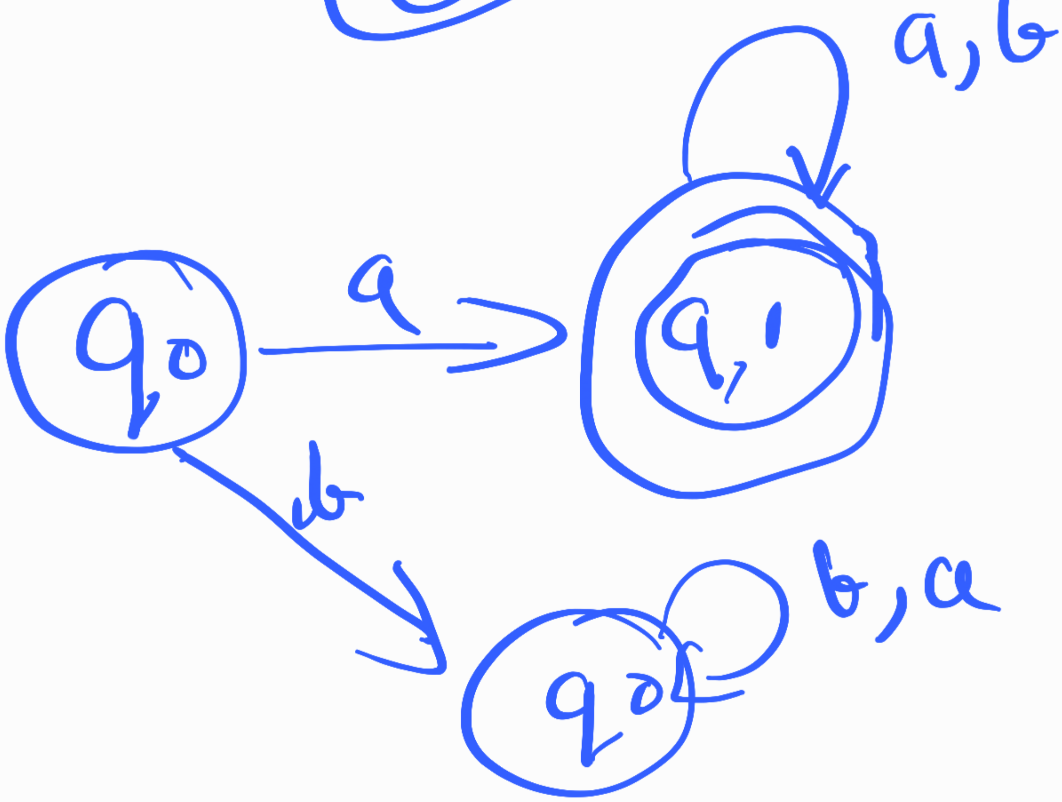


$L = \{aa\}$

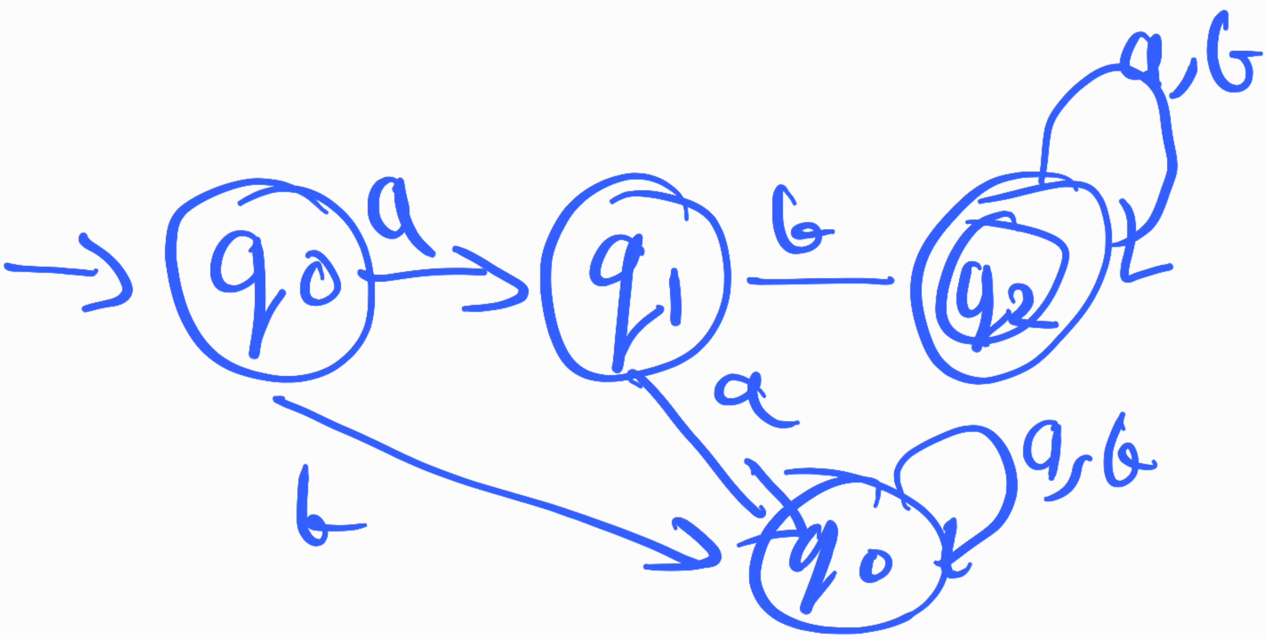


Now for a a b

b a



L = { string must start with ab }



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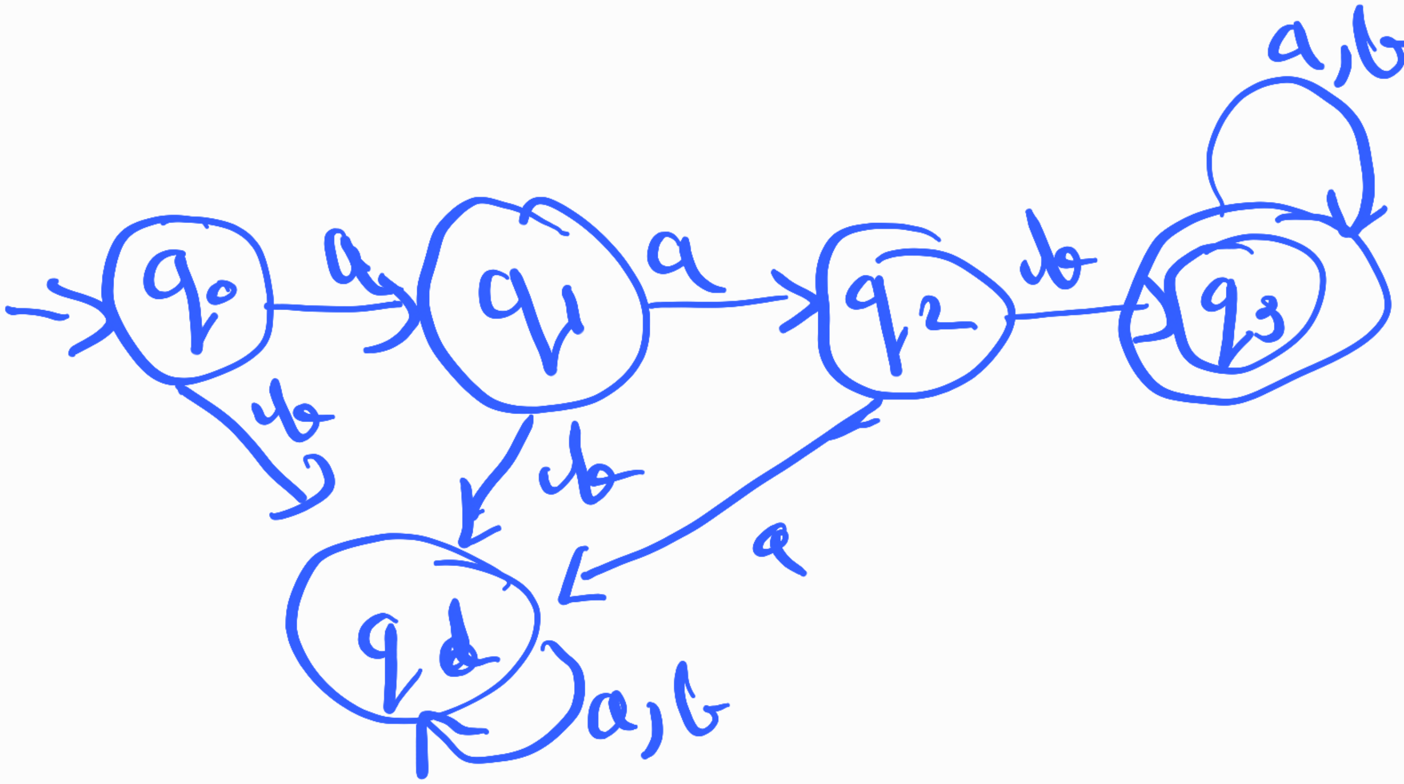
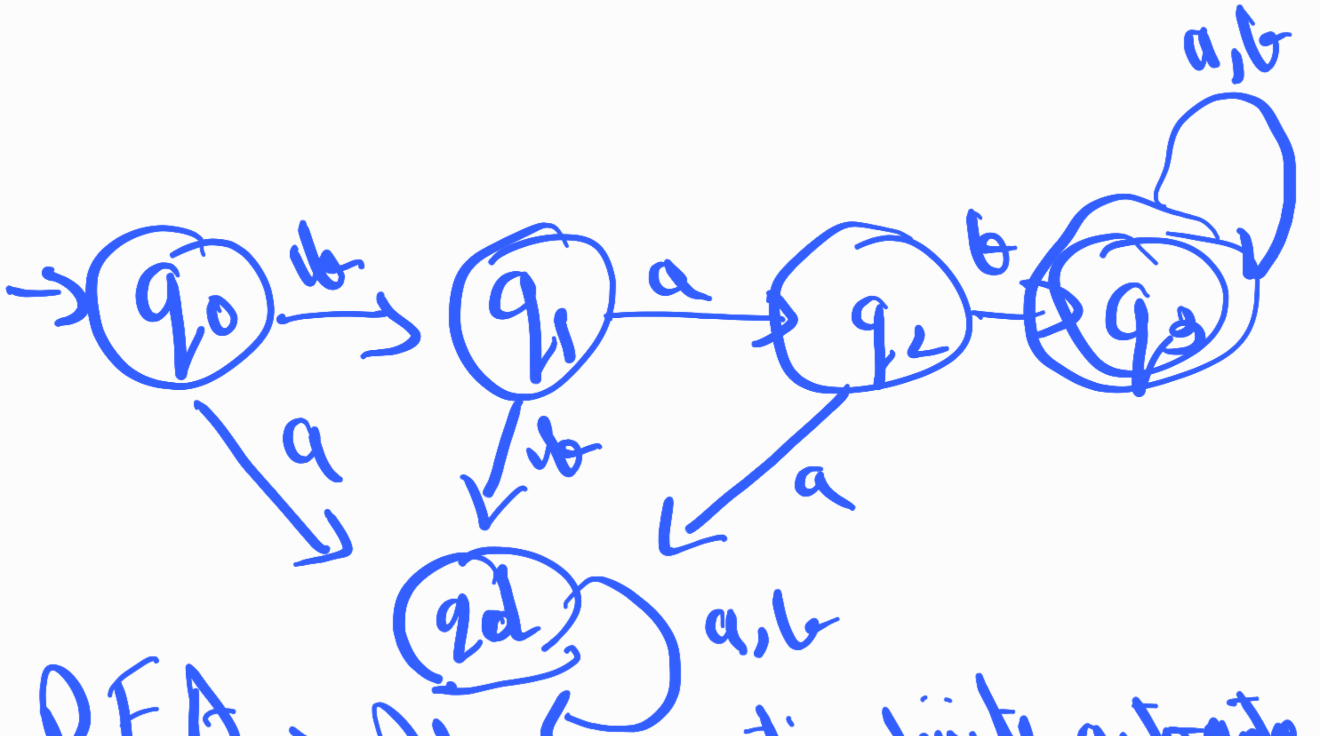
$L = \{$It should accept string starting from aab$\}$



$L_2 = \{$ starts with bab$\}$



DFA → Deterministic finite automata

DFA → has transition for all symbols.

$Q, \Sigma, \delta, q_0, f$

Q → set represents the number of states

$Q = \{q_0, q_1, q_2, q_3, q_4\}$

Σ → set of symbols in input

$\Sigma = \{a, b\}$

δ → transition function

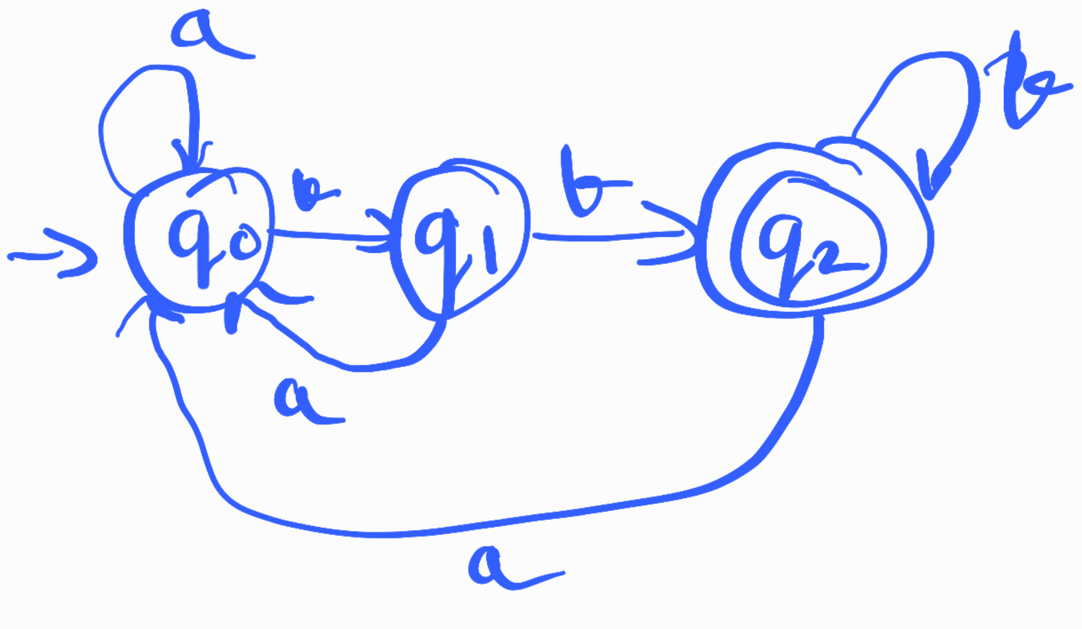
$\delta \to Q \times \Sigma \to Q$

current state   new input   new state

q_0 → initial state (only limited)

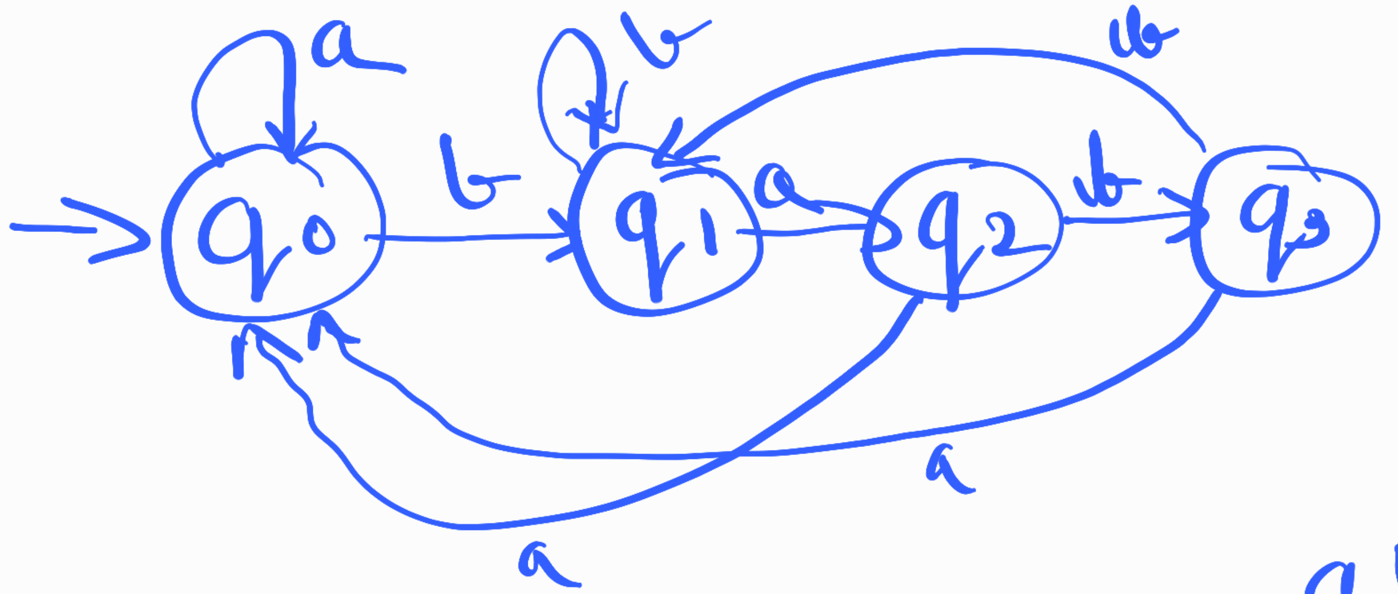
$F \rightarrow \{q_3\}$ 5 tuples
final state ↓
makes the definition
of a machine

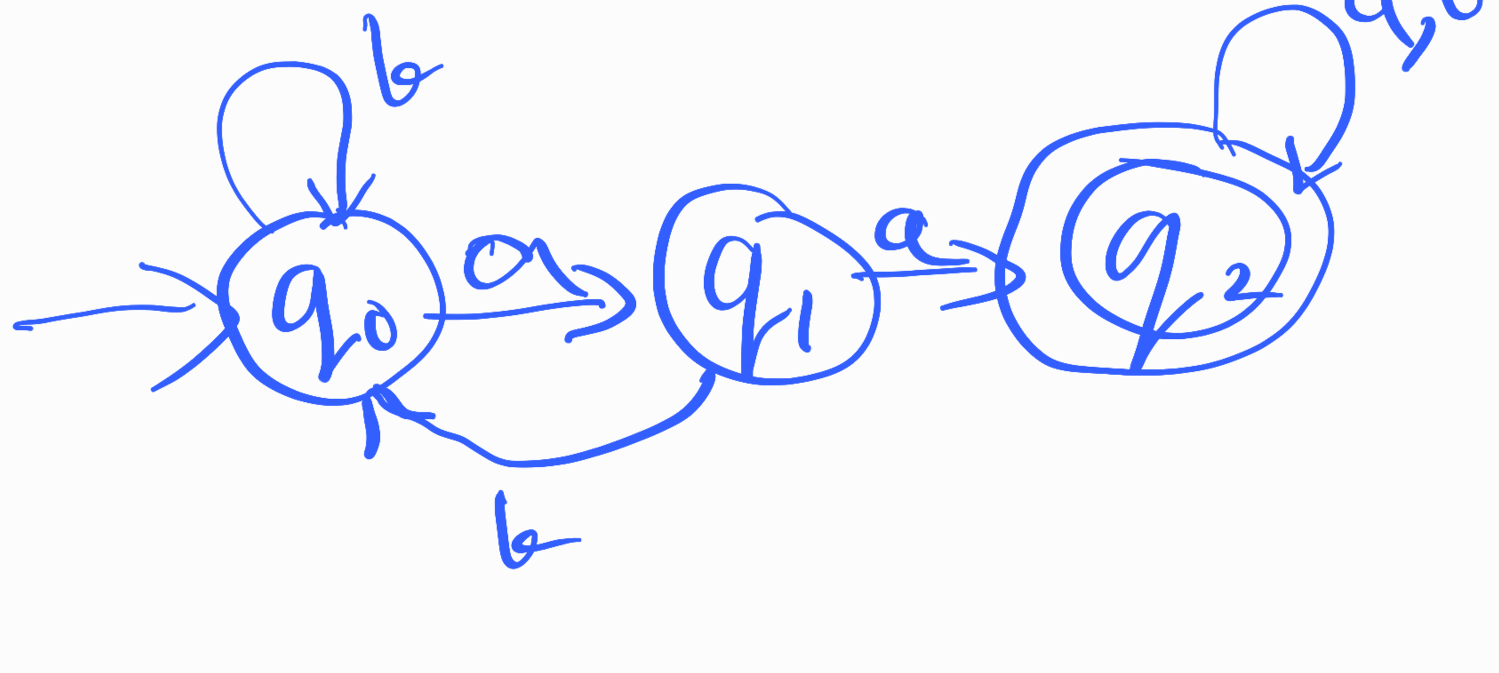
$L = \{$ string ending with bb $\}$



$L = \{$ string ends with ab $\}$

L = { ends with bab }





string starting with a

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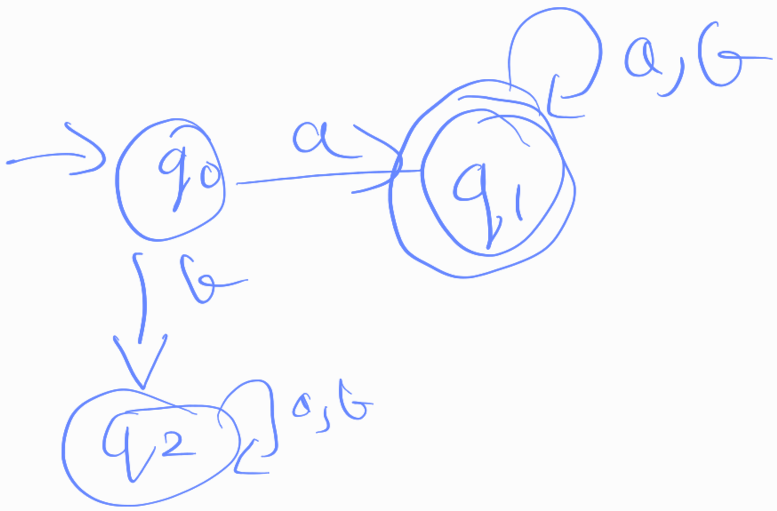

$q \backslash \Sigma$	a	b
q_0	q_1	q_2
q_1	q_1	q_1
q_2	q_2	q_2

5 tuples

Q → set of states

Σ → set of symbols

δ → transition function $\delta : Q \times \Sigma \to Q$

q_0 → initial state

F → set of final states

when it stops at final state

write

'aaba' accepted by language L

↑ example string

string → 6 len

def → state diagram → transition table

string acceptance

Q not 6 len → required

Q = set of states

Σ = Alphabetic set of tuples

δ = Transition function

$Q \times \Sigma = Q$ used to find next state

q_0 : Initial state

F : Final state

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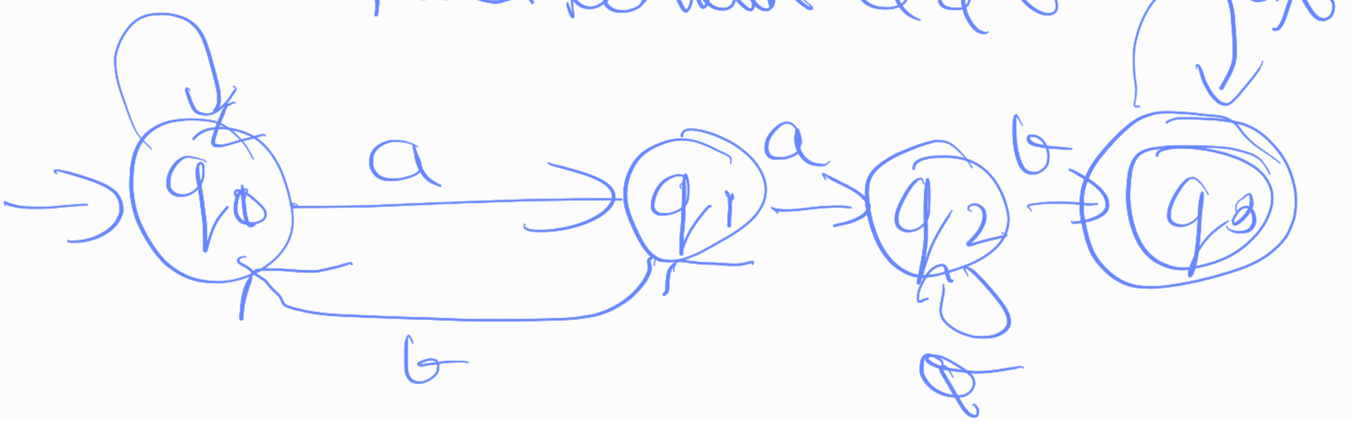
must contain aab



Q \ Σ	a	b
q_0	q_1	q_0
q_1	q_2	q_0
q_2	q_2	q_3
q_3	q_3	q_3

ababaab

$\delta(a, q_0) = q_1$

$\delta(b, q_1) = q_0$

$\delta(a, q_0) = q_1$

$\delta(b, q_1) = q_0$

$\delta(a, q_0) = q_1$

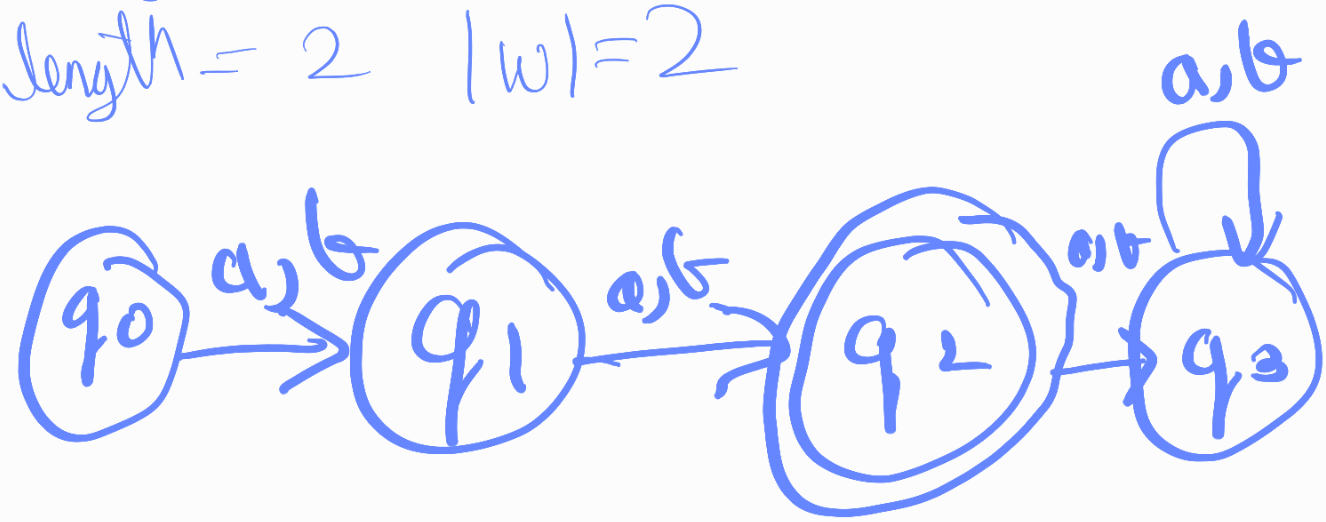
$\delta(a, q_1) = q_2$

$\delta(b, q_2) = q_3$

$\therefore$ the string ends on a final state

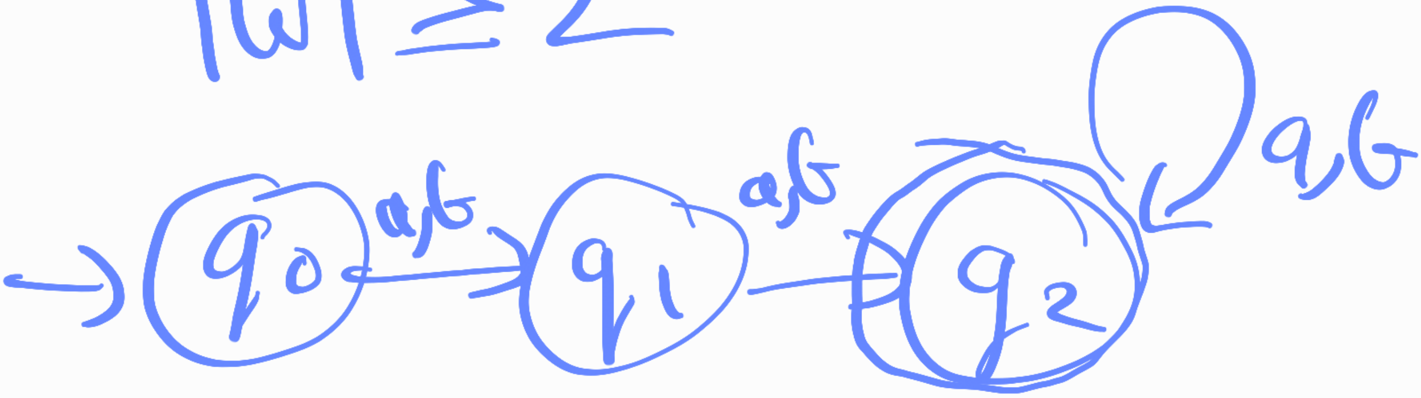
$\therefore$ it is accepted by the language

Design a dfa using alphabet set
$\Sigma = \{a, b\}$
every string accepted must have
length = 2 $|w| = 2$

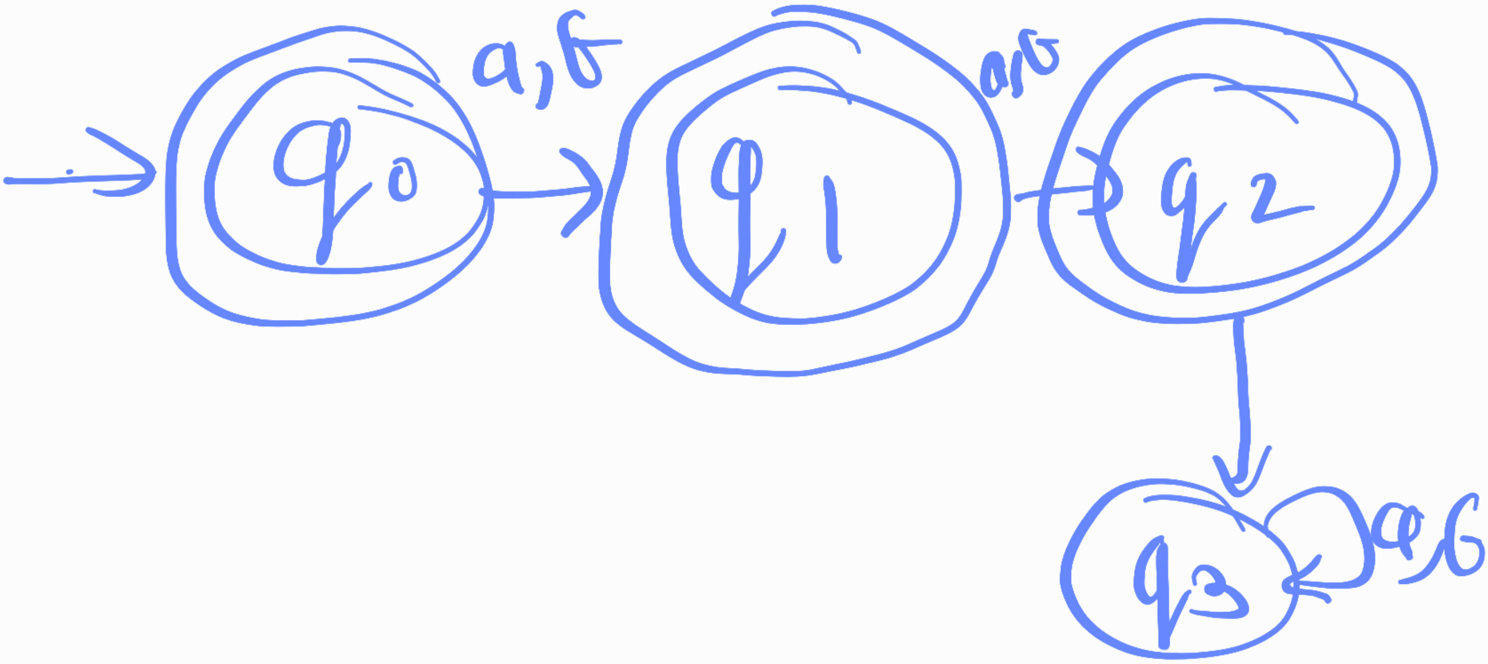


$q \backslash \Sigma$	a	b
q_0	q_1	q_1
q_1	q_2	q_2
q_2	q_3	q_3
q_3	q_3	q_3

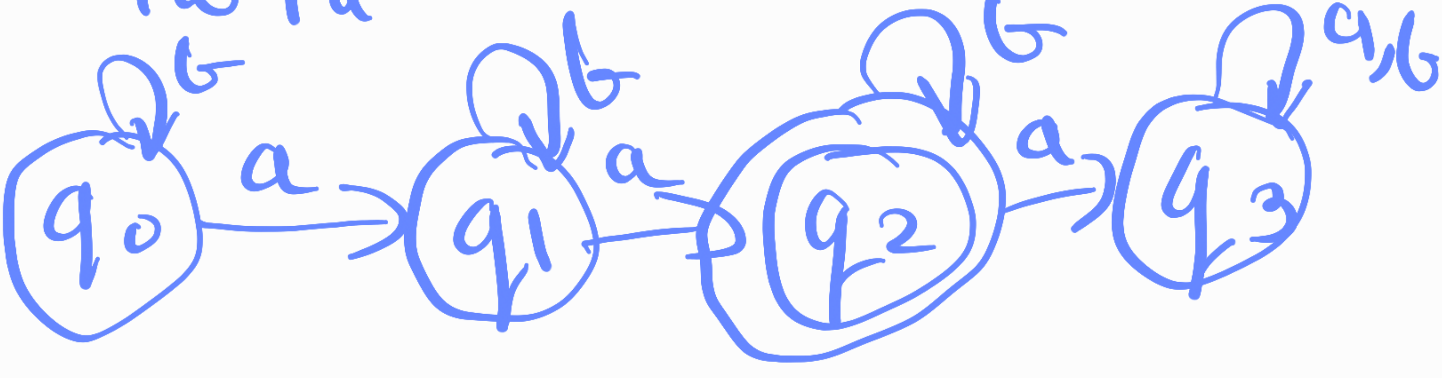
$|w| \geq 2$



$|w| \leq 2$



$|w|_a = 2$



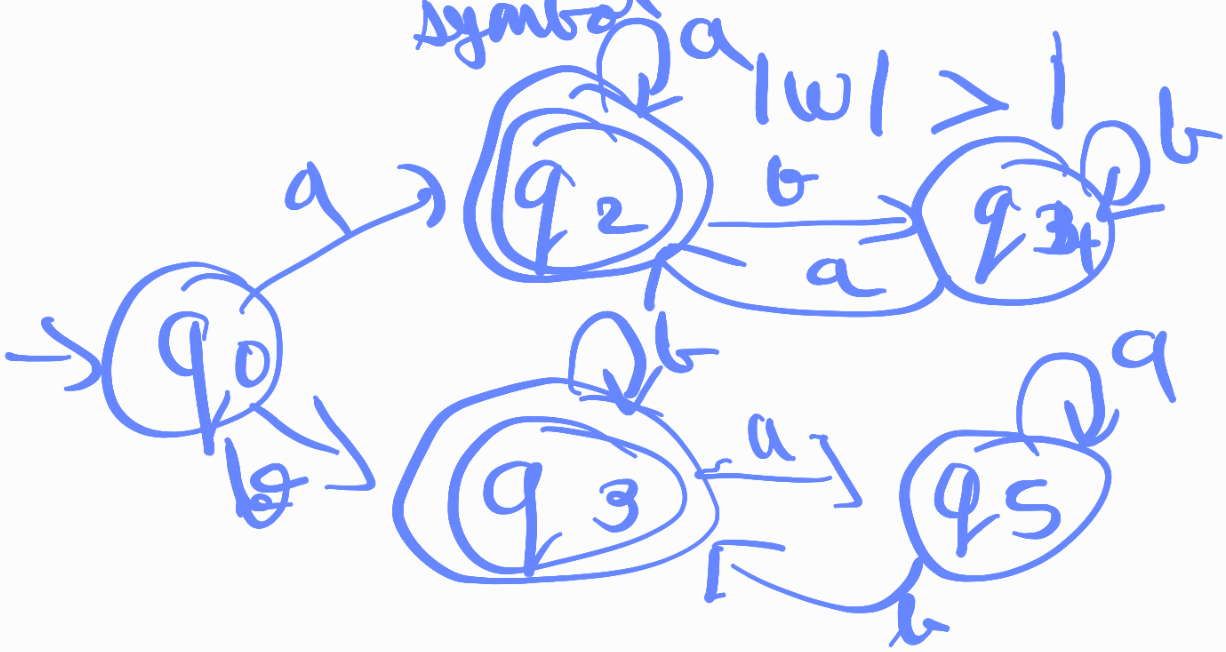
$|w|_a \geq 2$

$|w|_a \leq 2$

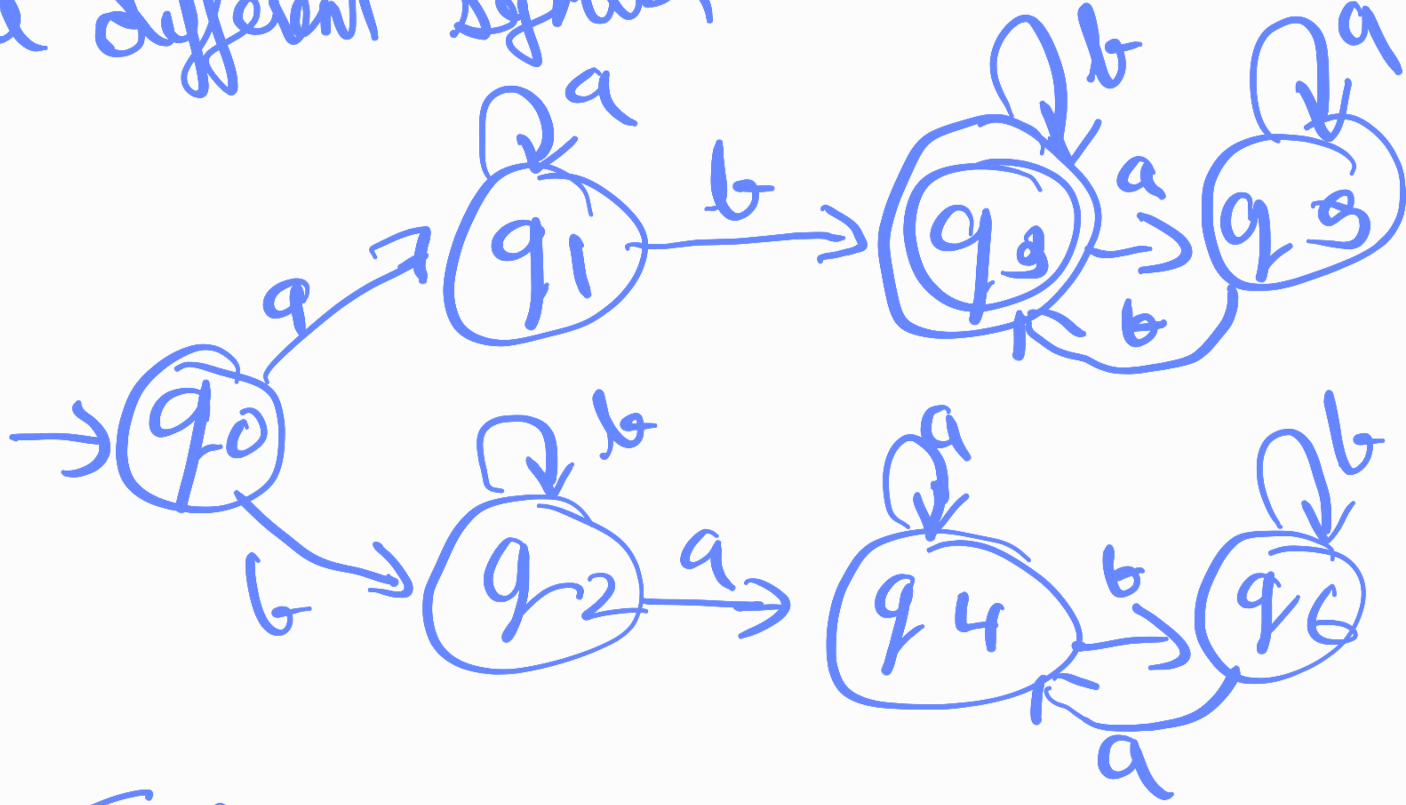
Design a DFA over $\Sigma\{a,b\}$

the string accepted must start and end with the same symbol

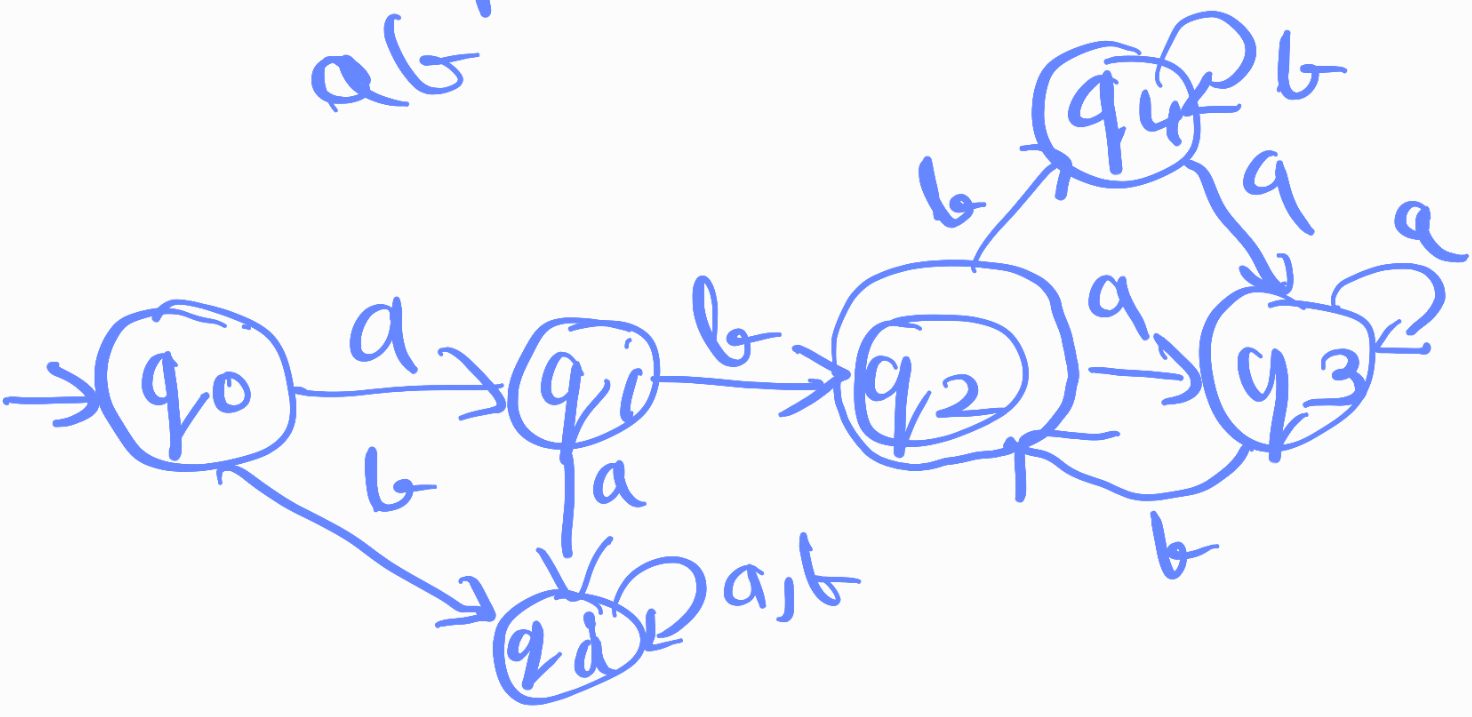
$|w| > 1$



Design a DFA over
Σ {a, b} such that every
string accepted must end with
a different symbol



DFA over a,b every string
accepted must start and end
ab



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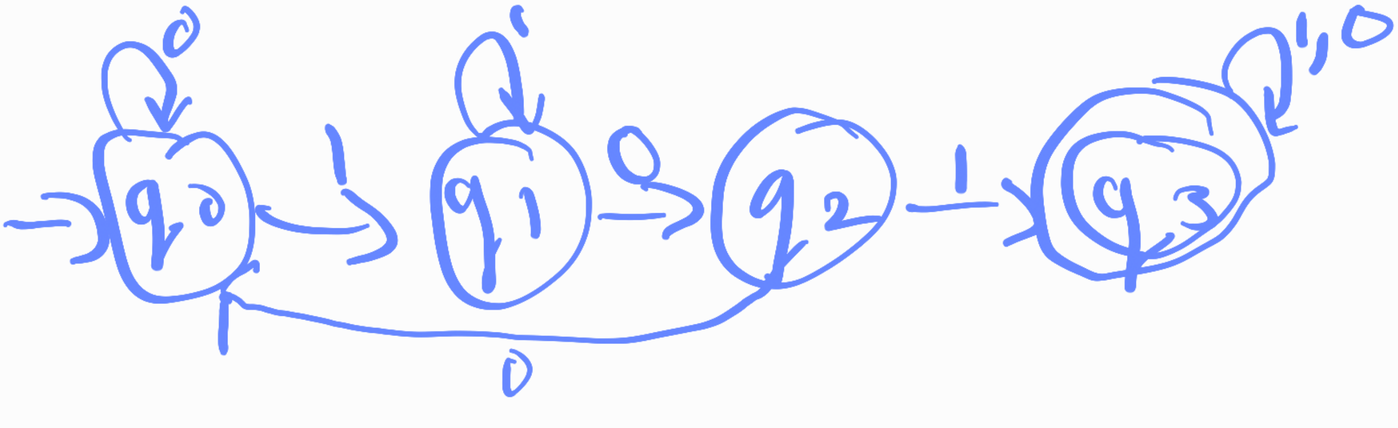
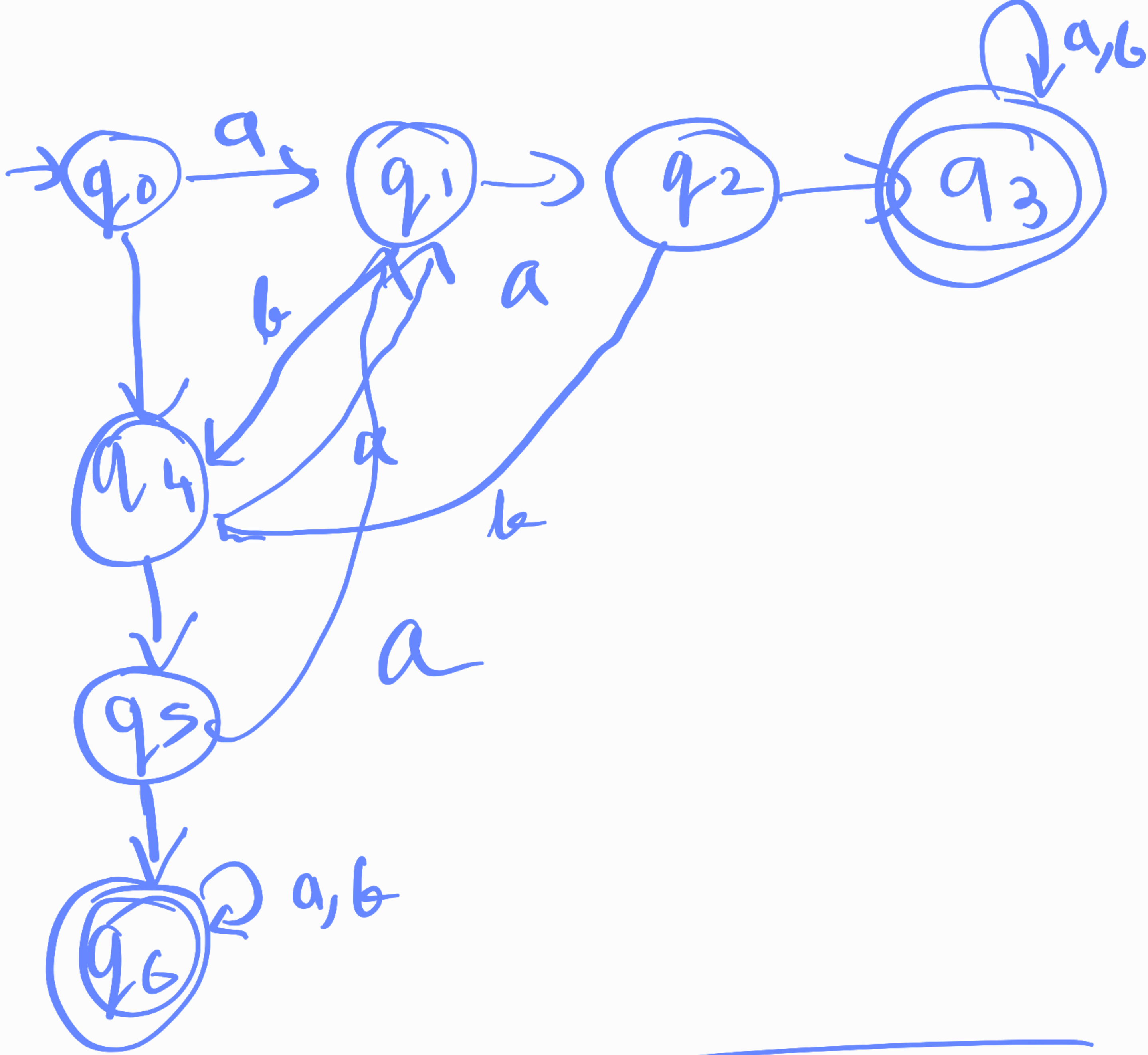
Q1. Design a DFA for the ~~alphabet set~~ Σ {0,1} which accepts a string which contain 101.

Q2. Design a DFA that accepts set of all string over Σ = a,b contains either subs aaa or bbb

Q3. Design a DFA Σ = (0,1) which accepts all string that contains substring 11 and c contain 00

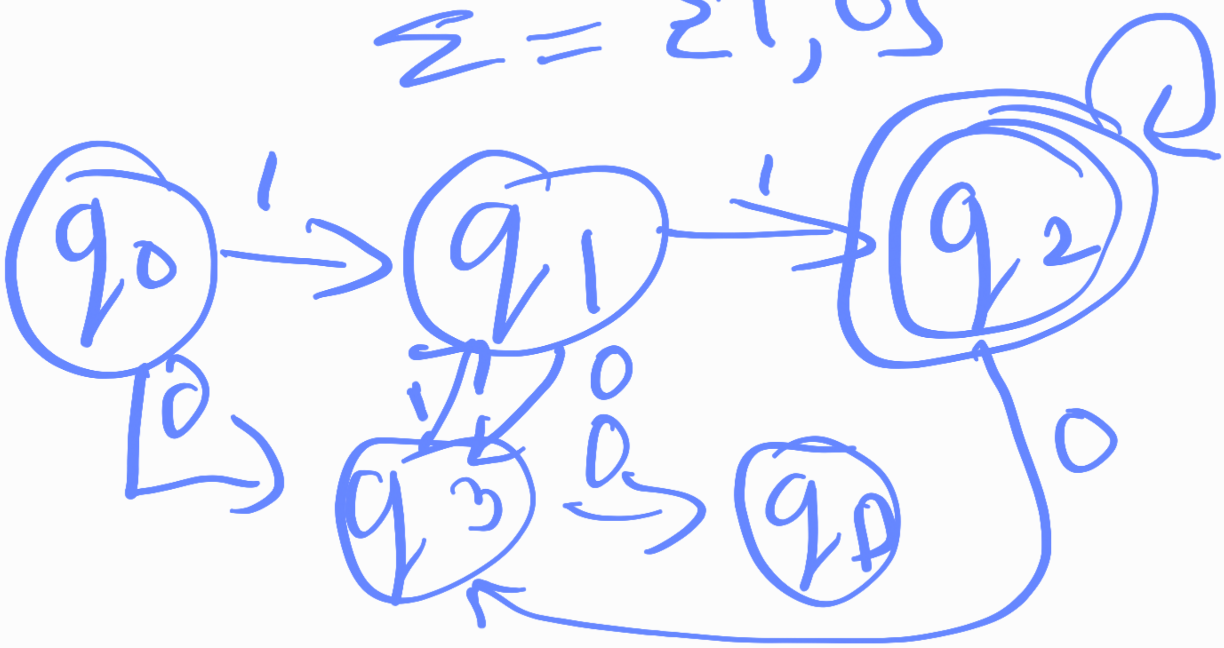
$\Sigma = \{1,0\}$ must contain 101

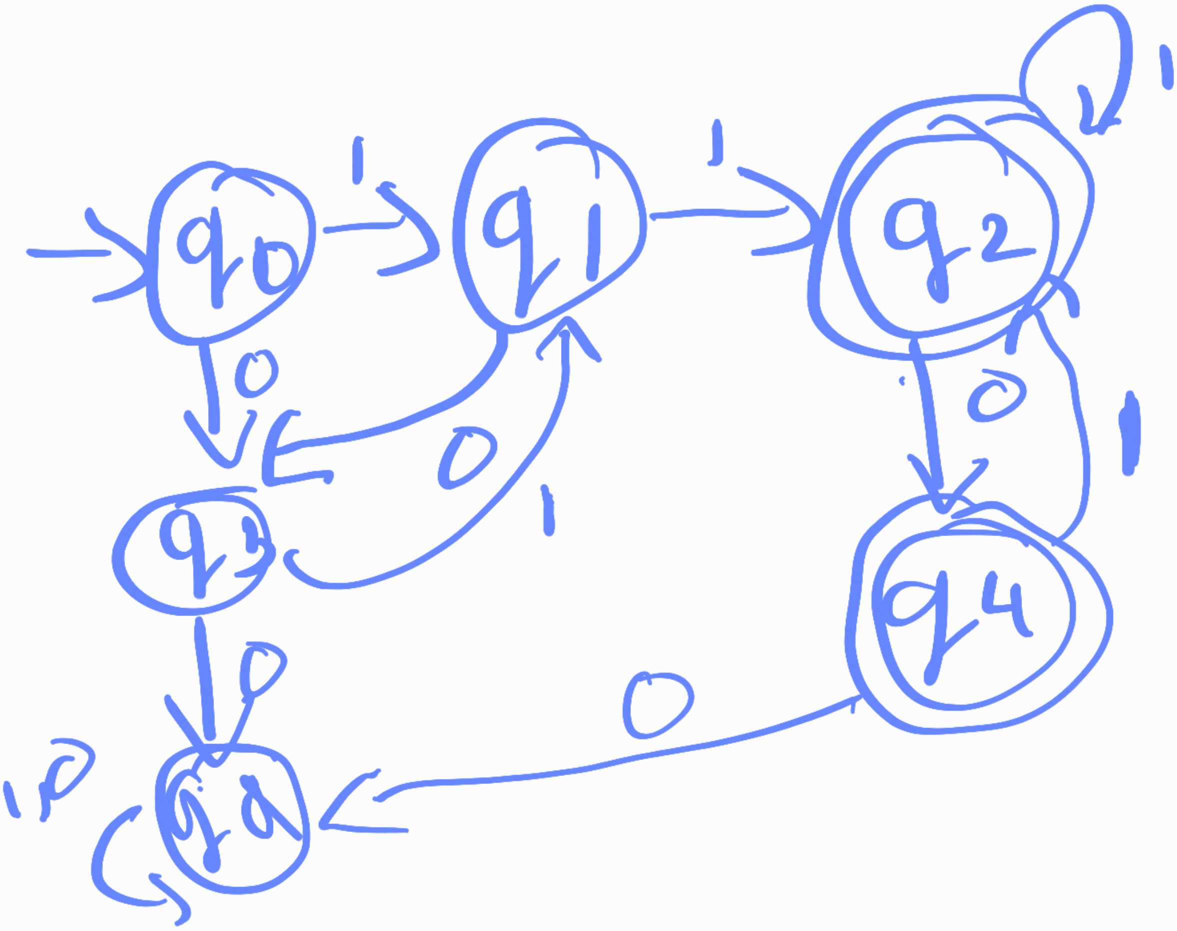




Contains 11 and not 00

$\Sigma = \{1, 0\}$




q0
q1
q2
q3
q4
qd
1
0

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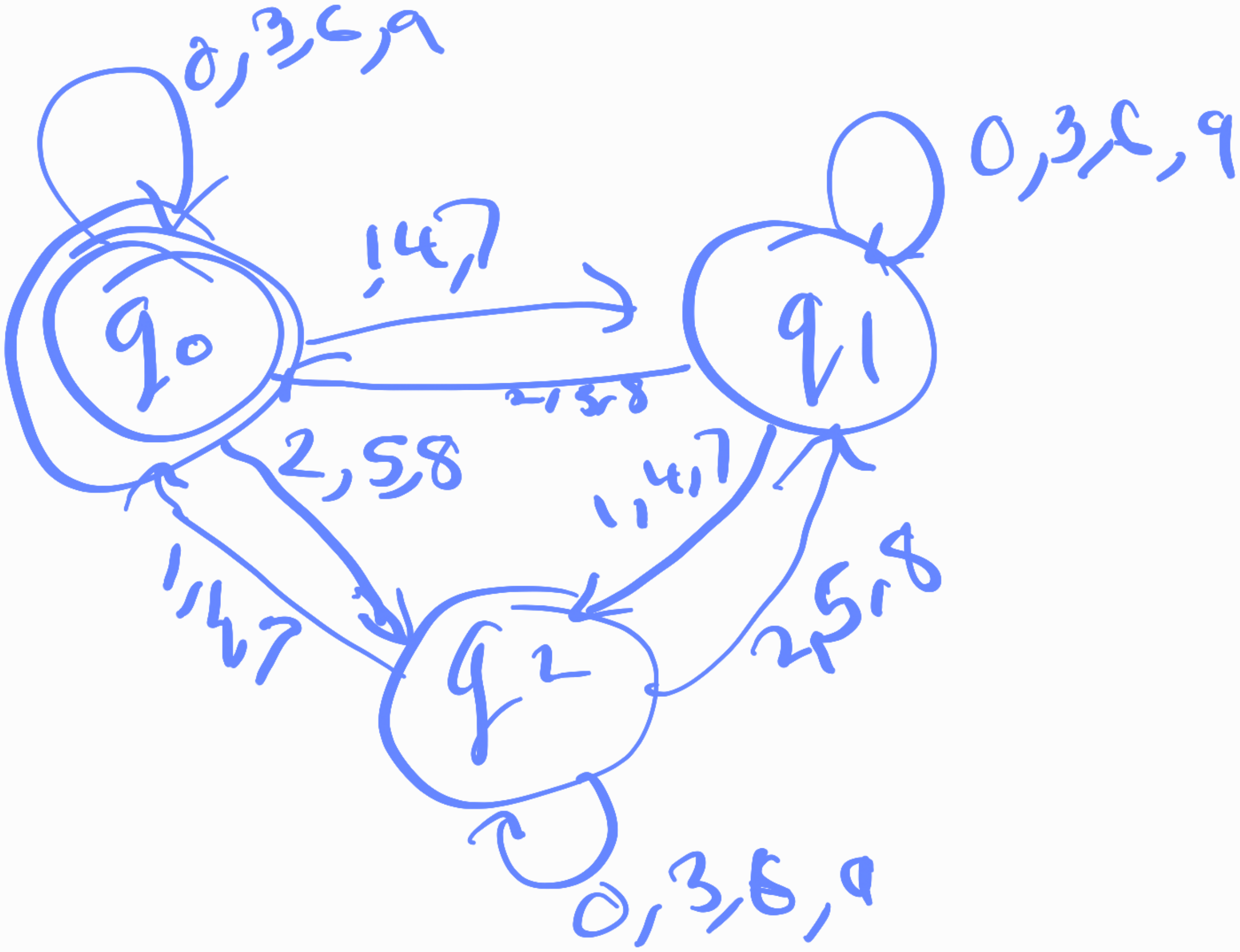
FA → FSM

$I = \{0,1,2,3,4,5,6,7,8,9\}$

$O = \{Y, N\}$



$0/3 = 3/3 = 6/3 = 0$ remainder → q_0

$1/3 = 4/3 = 7/3 = 1$ remainder → q_1

$2/3 = 5/3 = 8/3 = 2$ remainder

$Q \setminus \Sigma$	0,3,6,9	1,4,7	2,5,8
rem 0 q_0	q_0	q_1	q_2
rem 1 q_1	q_1	q_2	q_0
rem 2 q_2	q_2	q_0	q_1

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$\delta(q_0, 6) = q_0$

$\delta(q_0, 8) = q_2$

$\delta(q_2, 6) = q_2$

$\delta(q_2, 9) = q_2$

$\delta(q_2, 1) = q_0$

$\delta(q_0, 3) = q_0$

$\delta(q_0, 5) = q_2$

∴ The string ended on a non final state the string is not accepted in the language.

Design a DFA whether a number is divisible by foll –

a) 4

b) 2

c) 5

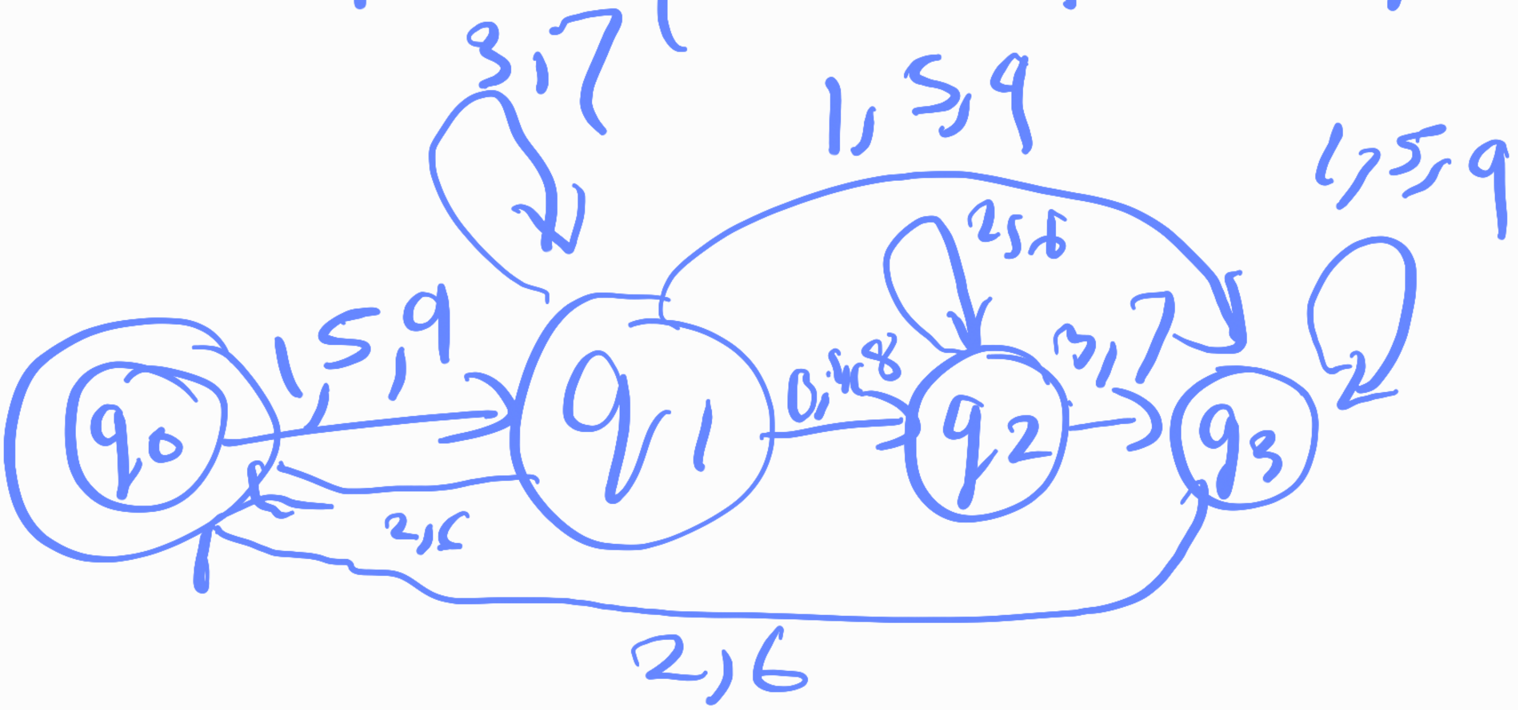
$\frac{0}{4} = \frac{4}{4} = \frac{8}{4} = 0$ remainder

$\frac{1}{4} = \frac{5}{4} = \frac{9}{4} = 1 \rightarrow$ remainder

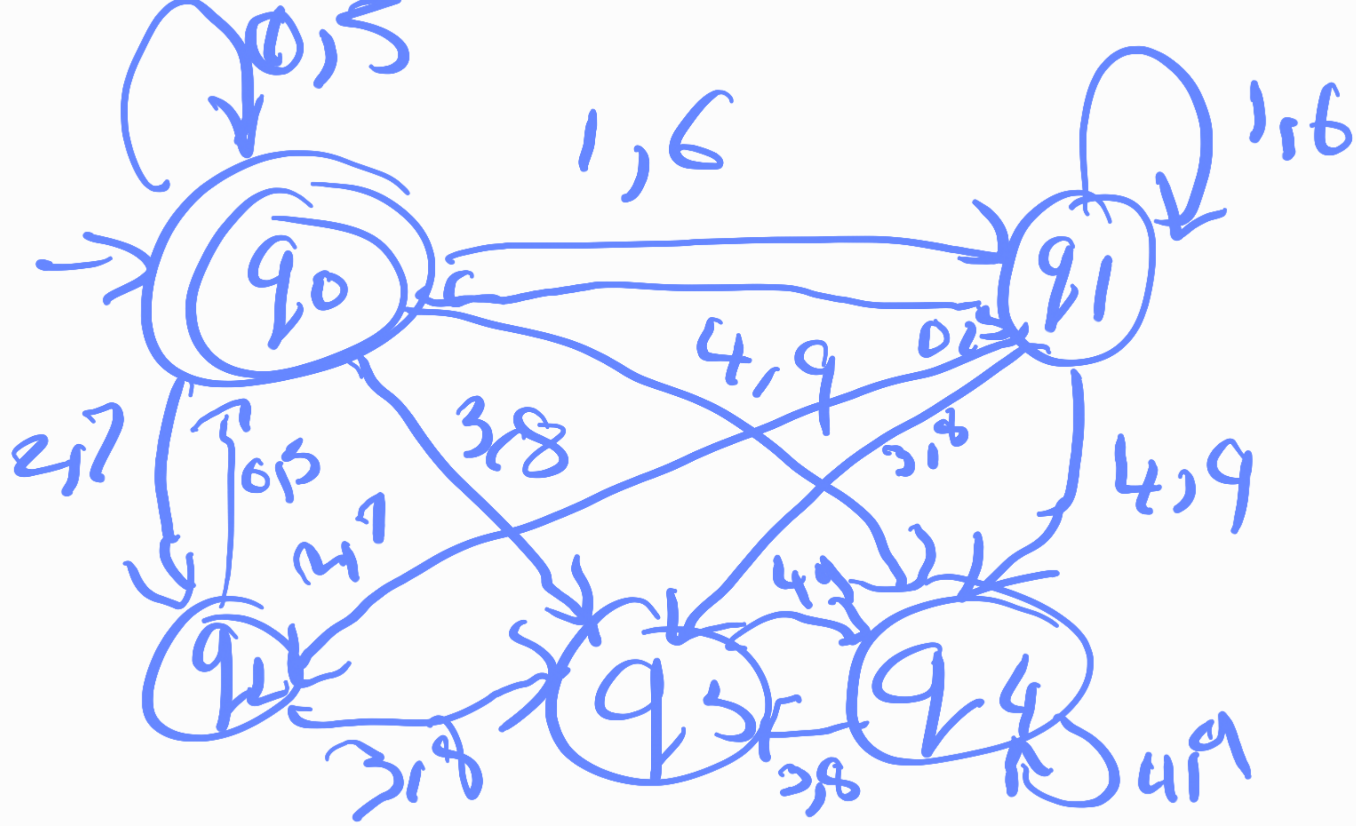
$\frac{2}{4} = \frac{6}{4} = 2 \rightarrow$ remainder

$\frac{3}{4} = \frac{7}{4} = 3$

Σ	0,4,8	1,5,9	2,6	3,7
rem 0 q_0 F	q_0	q_1	q_2	q_3
rem 1 q_1	q_2	q_3	q_0	q_1
rem 2 q_2	q_0	q_1	q_2	q_3
rem 3 q_3	q_2	q_3	q_0	q_1



q \ Σ	0,5	1,6	2,7	3,8	4,9
rem0	q_0	q_1	q_2	q_3	q_4
rem 1	q_0	q_1	q_2	q_3	q_4
rem2	q_0	q_1	q_2	q_3	q_4
rem3	q_0	q_1	q_2	q_3	q_4
rem 4	q_0	q_1	q_2	q_3	q_4



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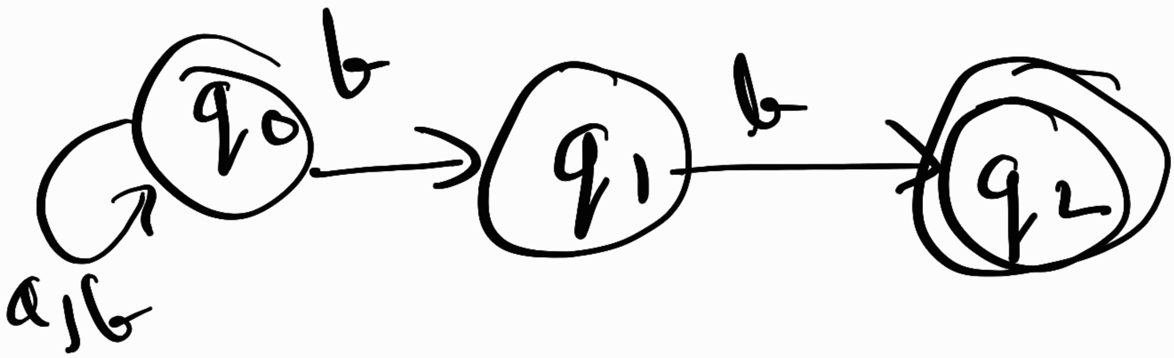
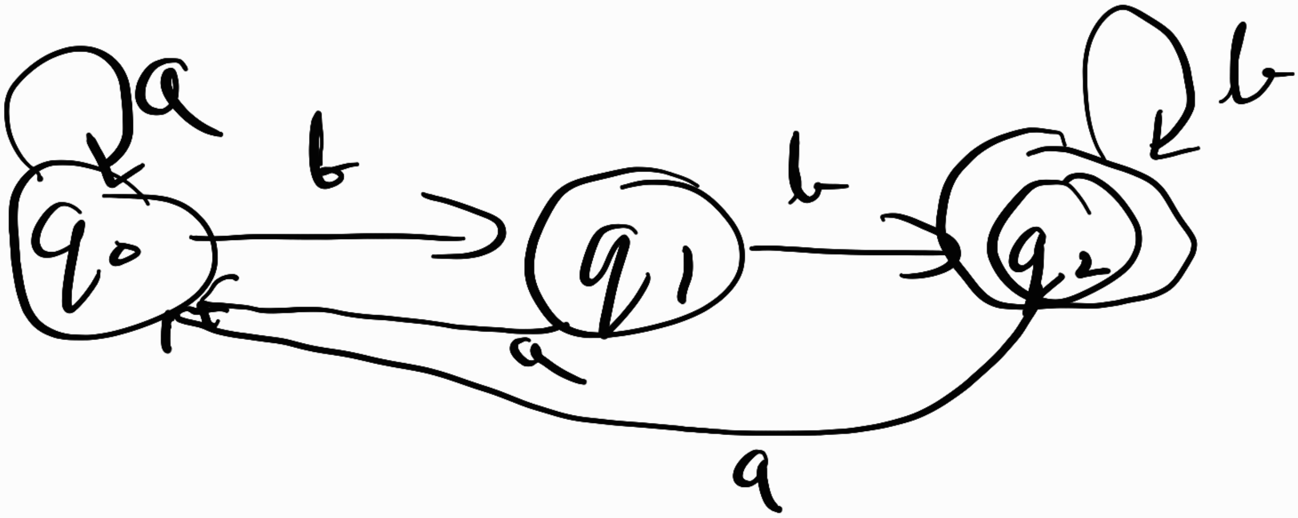
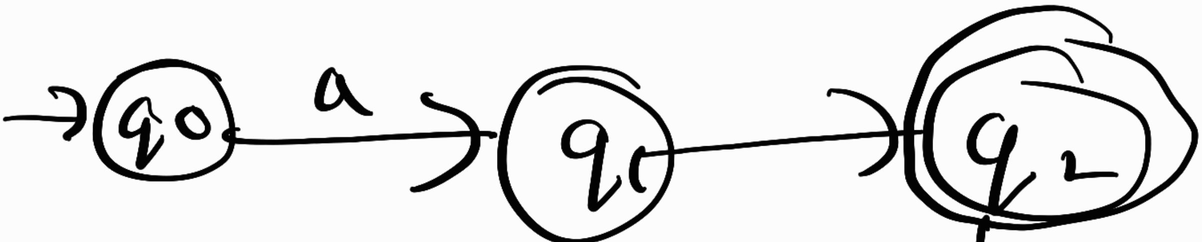


q \ Σ	a	b
q_0	q_0	$\{q_0, q_1\}$
q_1	–	q_2
q_2	–	–

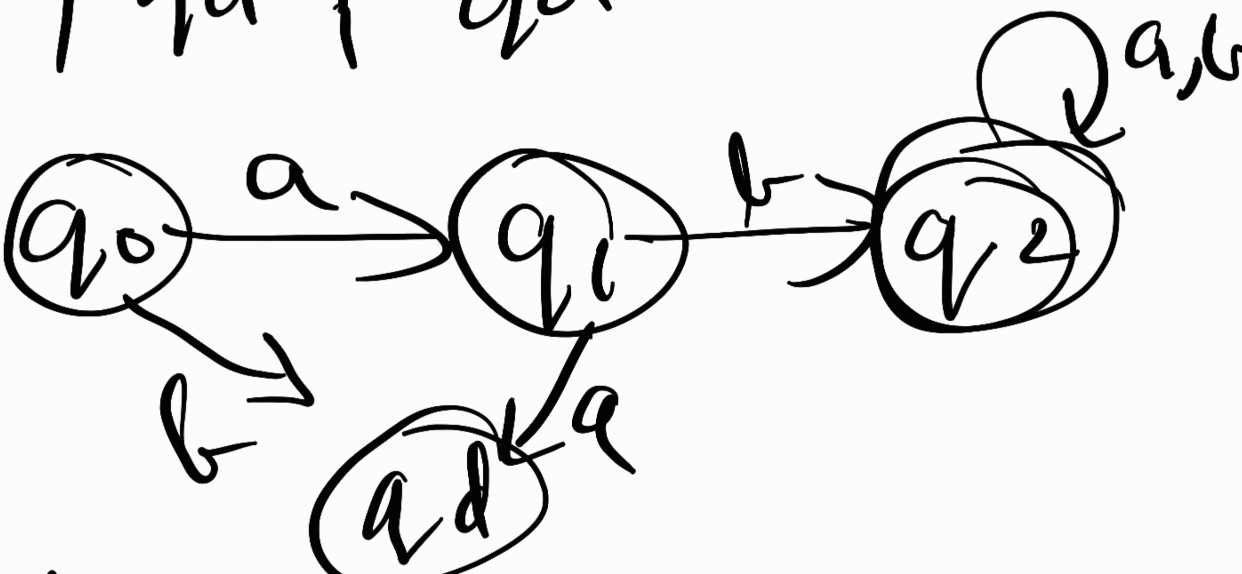
$q \backslash \Sigma$	a	b
q_0	q_0	$\{q_0, q_1\}$
$\{q_0, q_1\}$	q_0	$\{q_0, q_1, q_2\}$
$\{q_0, q_1, q_2\}$	q_0	$\{q_0, q_1, q_2\}$

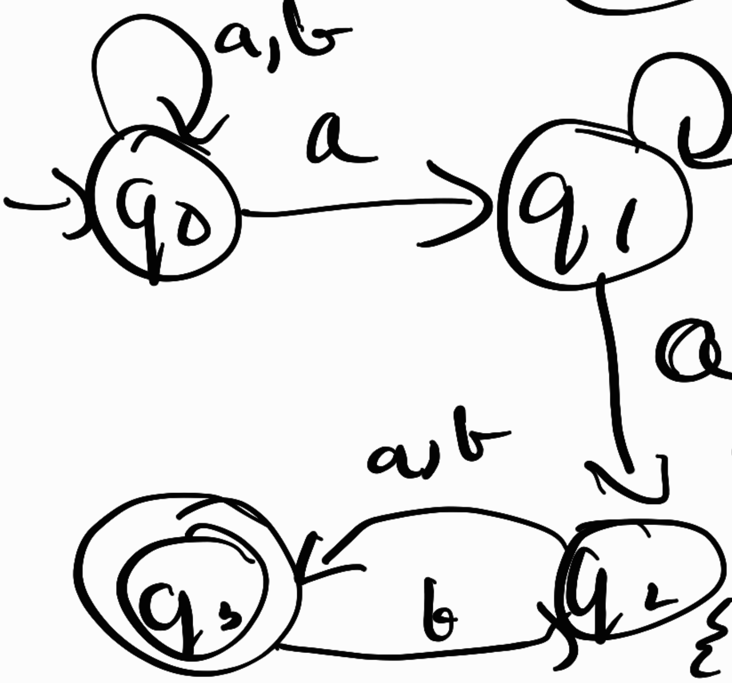




	a	b
q_0	q_1	—
q_1	—	q_2
q_2	q_2	q_2

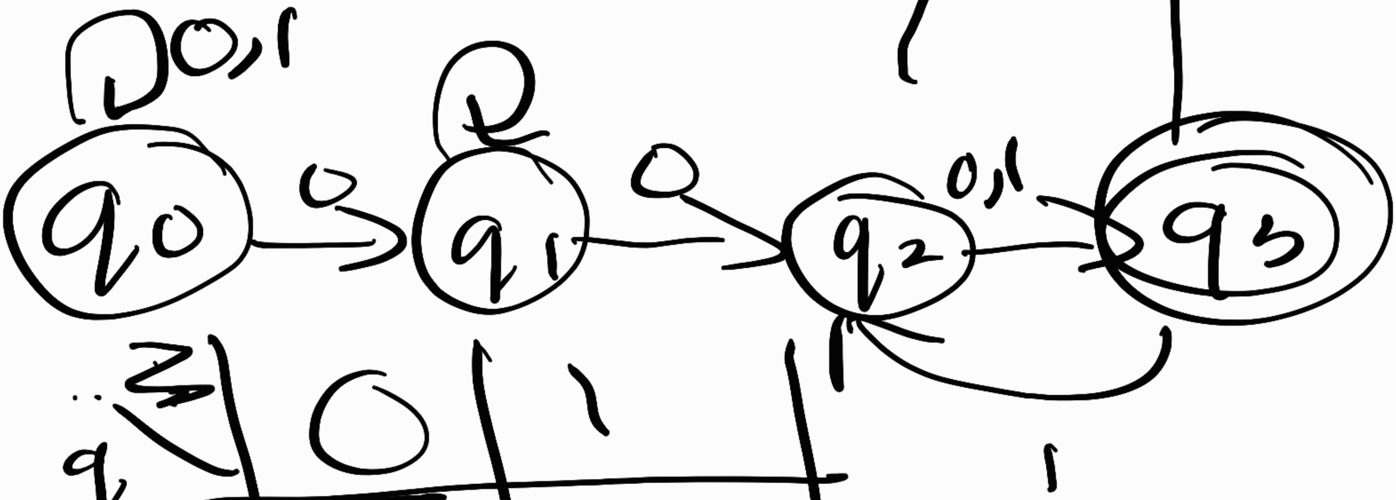
$q \backslash \Sigma$	a	b
q_0	q_1	q_d
q_1	q_d	q_2
q_2	q_2	q_2
q_d	q_d	q_d





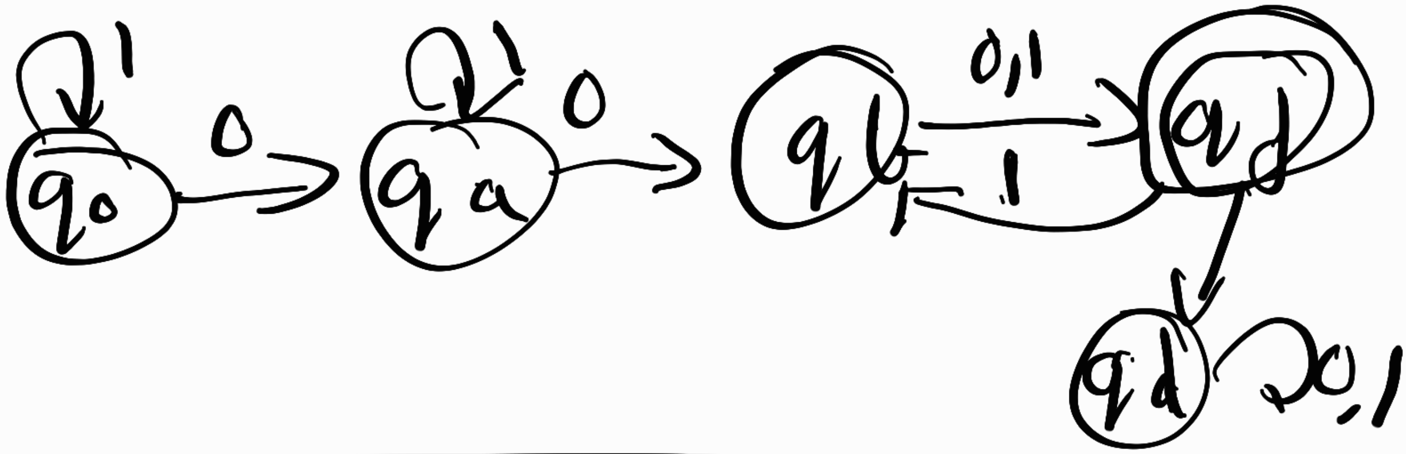
$q \backslash \Sigma$	a	b
q_0	$\{q_0,q_1\}$	q_0
$\{q_0,q_1\}$	$\{q_0,q_1,q_2\}$	$\{q_0,q_1\}$
$\{q_0,q_1,q_2\}$	$\{q_0,q_1,q_2,q_3\}$	→ same

{q0, q1, q2, q3} | qd | {q0, q1, q2}

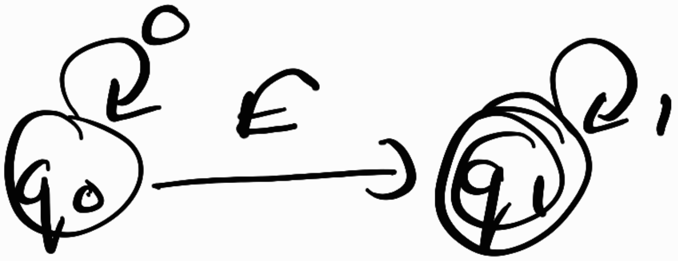


q \ Σ	0	1
q0	{q0, q1}	q0
q1	q2	q1
q2	q3	q3
q3	—	q3

q \ Σ	0	1
q0	{q0, q1}	q0
{q0, q1}	{q0, q1, q2}	{q0, q1}
{q0, q1, q2}	{q0,	q1, q3}
{q0, q1, q2, q3}	q0, q1, q3 ϕ	q0, q1, q2



$$\delta' = \epsilon\text{-closure}(\delta(\epsilon\text{-closure}(q), x))$$

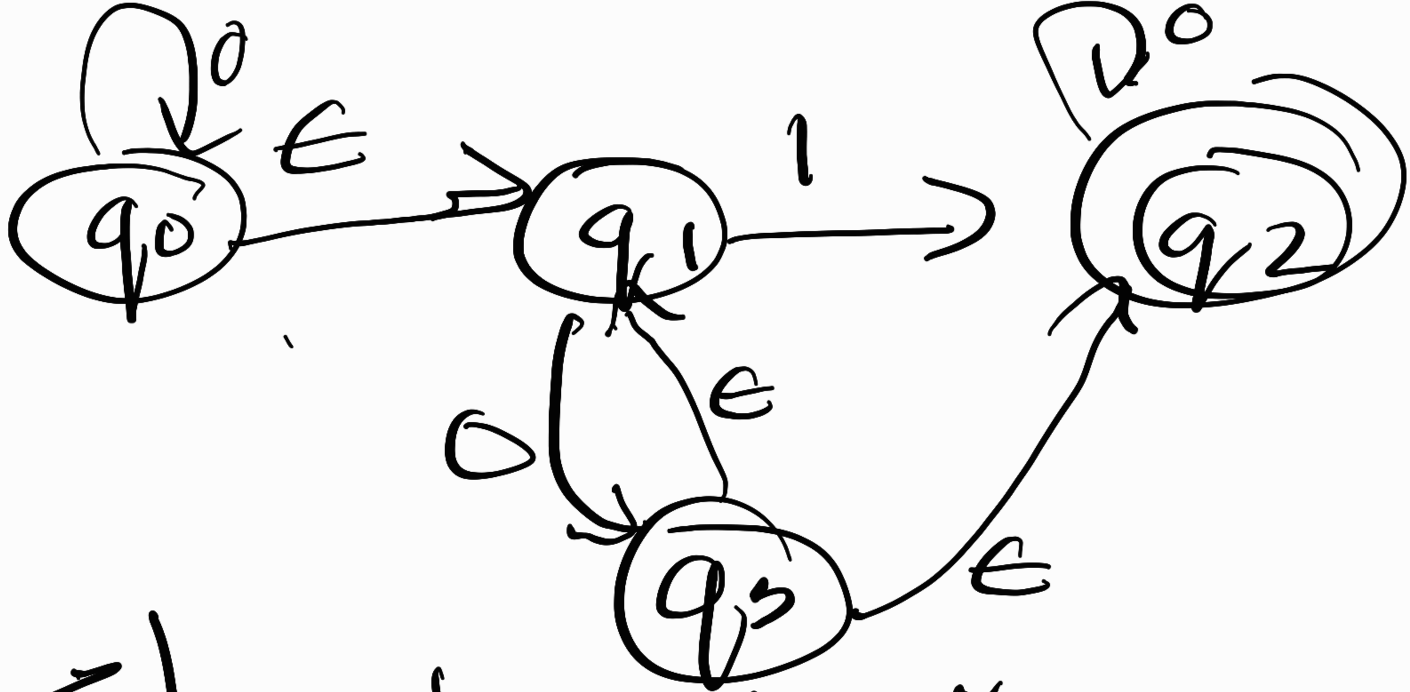


$q \backslash \Sigma$	0	1	ϵ^*
q_0	q_0	ϕ	$\{q_0, q_1\}$
q_1	ϕ	q_1	$\{q_1\}$

$$\delta'(q_0, 0) = \epsilon\text{ closure}(\delta(\epsilon\text{ closure}(q_0), 0))$$

$$= \epsilon\text{ closure}(\delta(q_0, q_1, 0))$$

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



$q \backslash \Sigma$	0	1	Σ^*
q_0	q_0	ϕ	$\{q_0, q_1\}$
q_1	q_3	q_2	$\{q_1\}$
q_2	q_2	ϕ	$\{q_2\}$
q_3	ϕ	ϕ	$\{q_1, q_2, q_3\}$

$$\delta'(q_0, 0) = \{q_0, q_1\} \rightarrow \delta 0$$

$$\rightarrow \{q_0, q_3\}$$

$\delta'(q_0, 1) = \{q_0, q_1\} \to 1$

$\to q_2$

$\delta'(q_1, 0) = \{q_1\} \to \delta 0$

$\to q_3 \to \{q_1, q_2, q_3\}$

$\delta(q_1, 1) = \{q_1\} \to \delta 1$

$q_2 \to \{q_2\}$

$\delta(q_2, 0) = \{q\} \to \delta 0$

$\to q_2$

$\delta(q_2, 1) = \{q_2\} \to \delta 1$

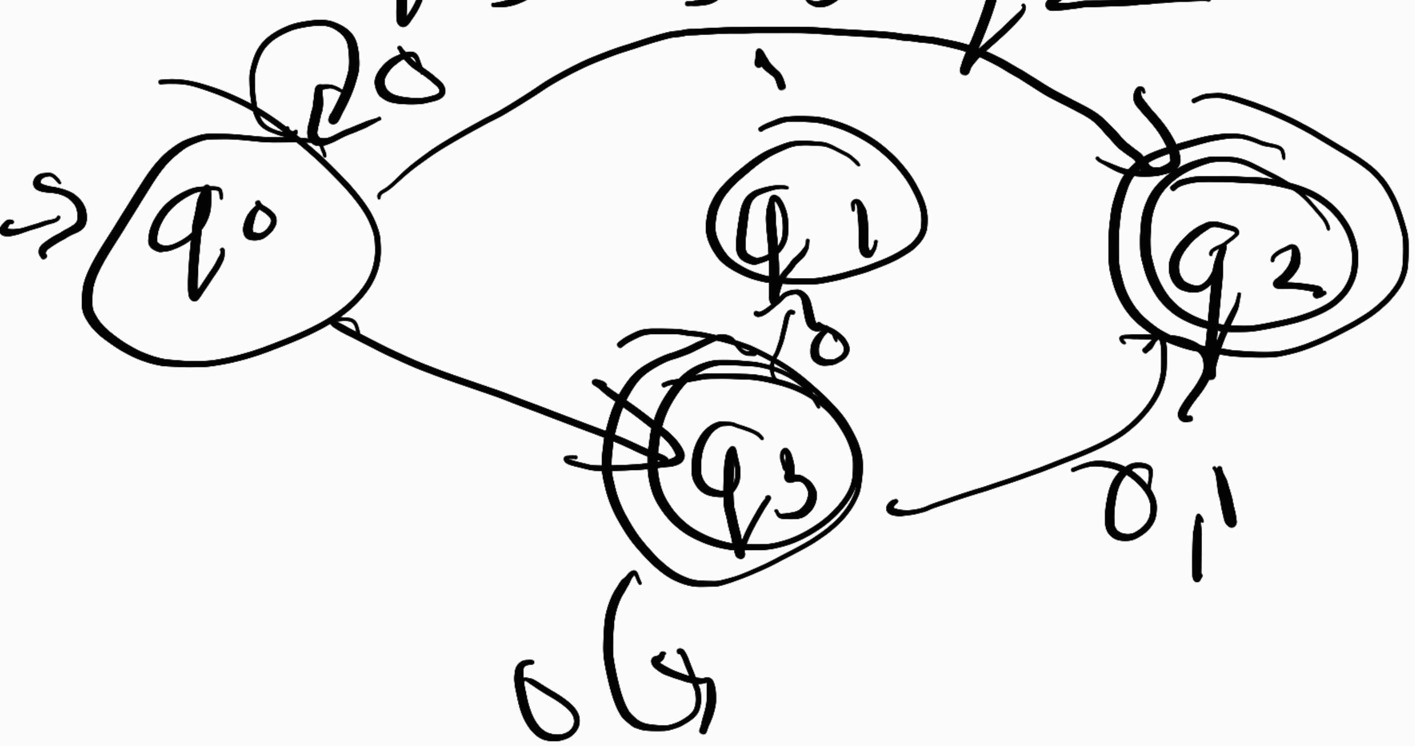
$\to \phi$

$\delta(q_3, 0) = q_1 q_2 q_3 \rightarrow \delta 0$

$q_3 q_2$

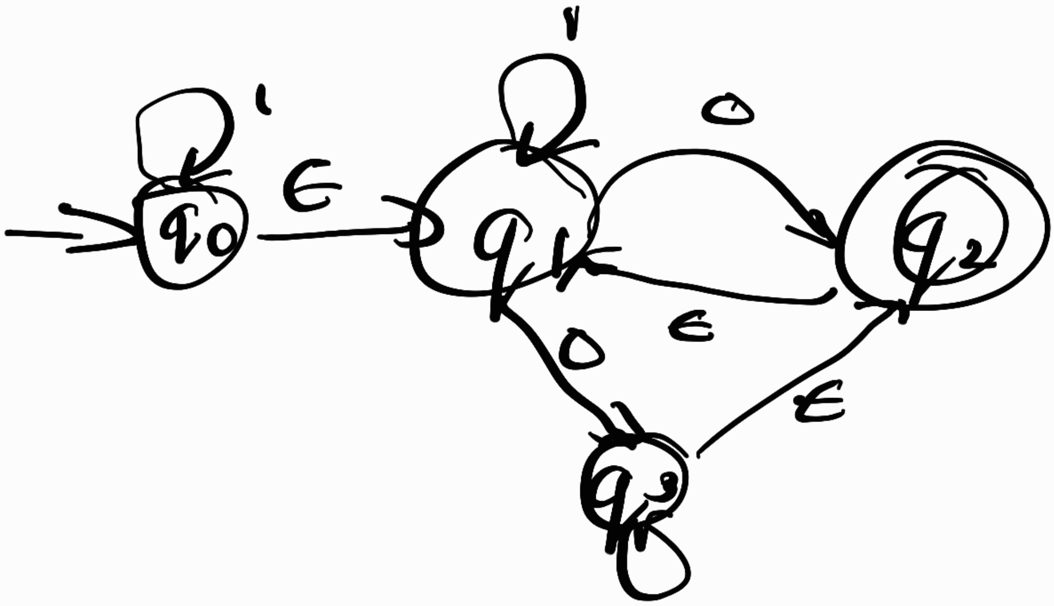
$= \{q_1 q_2 q_3\}$

$\delta(q_3, 1) \rightarrow q_2$



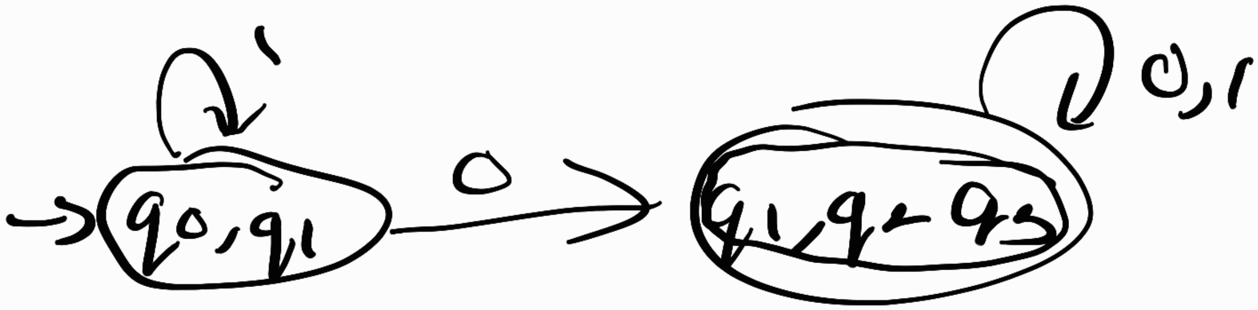
ϵNFA → DFA

$$\delta'(q, x) = \epsilon\text{-closure}(\delta(q, x))$$



$q \backslash \Sigma$	0	1	ϵ^*
q_0	ϕ	q_0	$\{q_0, q_1$
q_1	$\{q_2, q_3\}$	q_1	q_1
q_2	ϕ	ϕ	$\{q_2, q_1\}$

q_0 | $\emptyset$ | q_0 | $\{q_2, q_1\}$



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a^* ← kleen closure

$L = \{\epsilon, a, aa, a \ldots\}$

↳ for any symbol you can add that symbol any number of time.

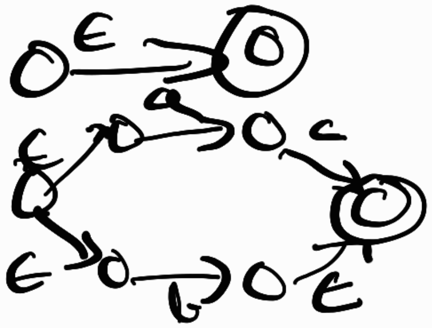
$a^+ \Rightarrow$ positive closure

$L = \{a, aa, aa\}$

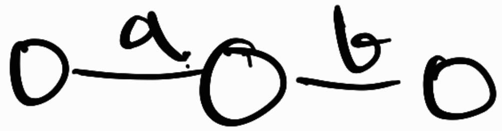
same as above but does not include ϵ

$r = \epsilon$

$r = a + b$

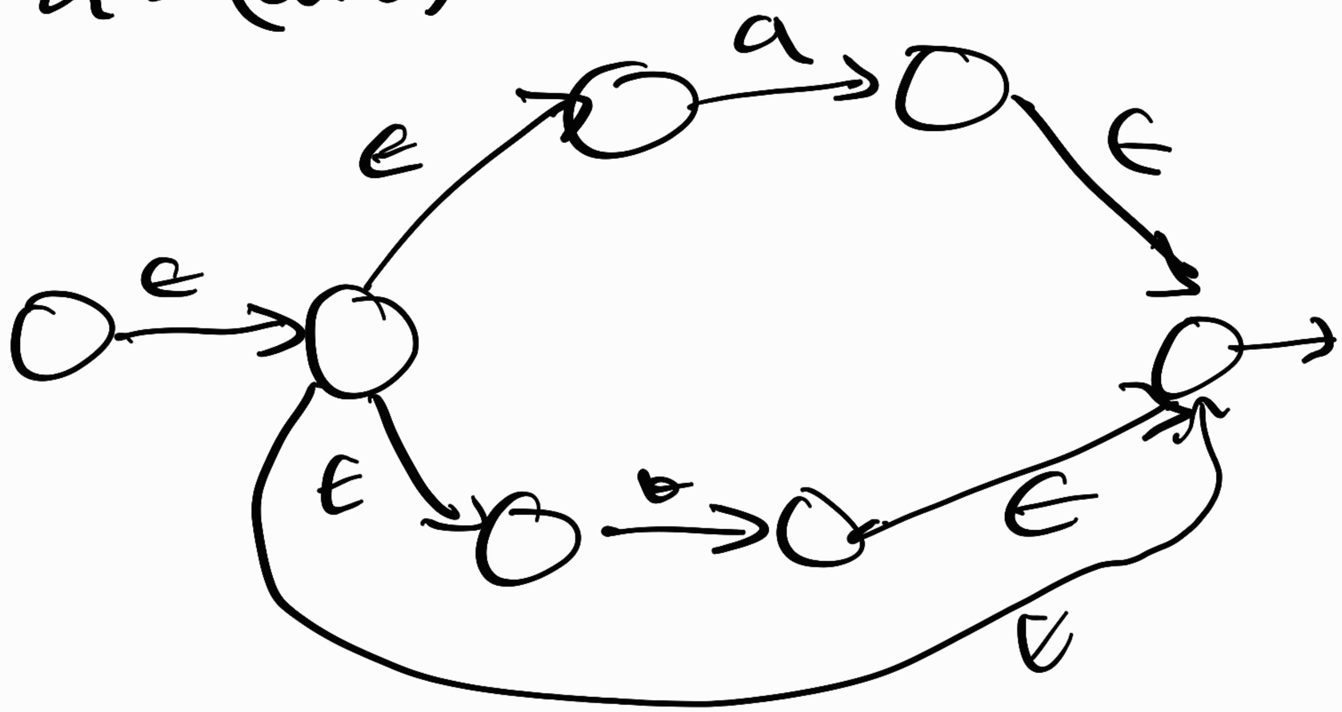


$r = a \cdot b$

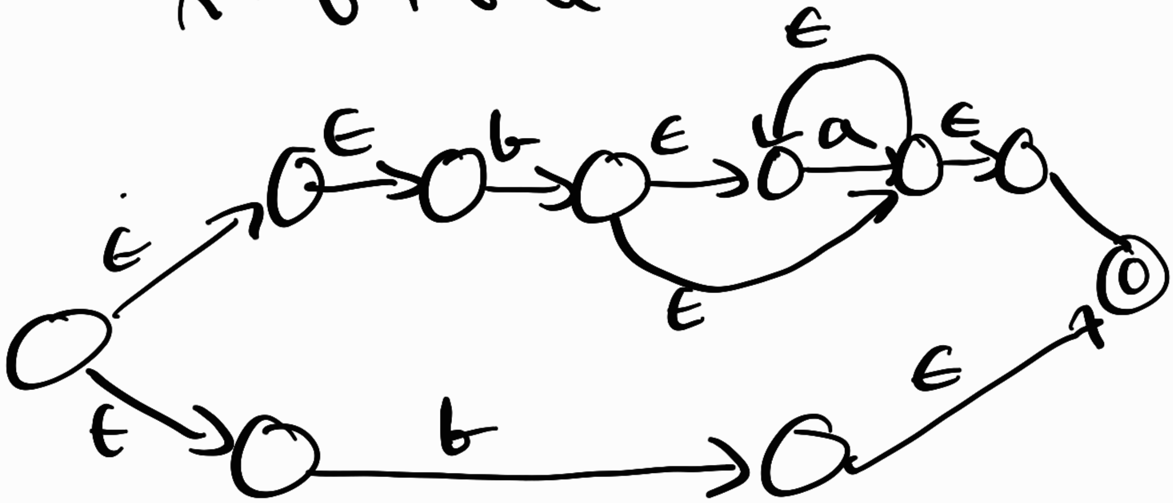


$r = a^* \rightarrow \{\epsilon, a, aa, aaa\}$

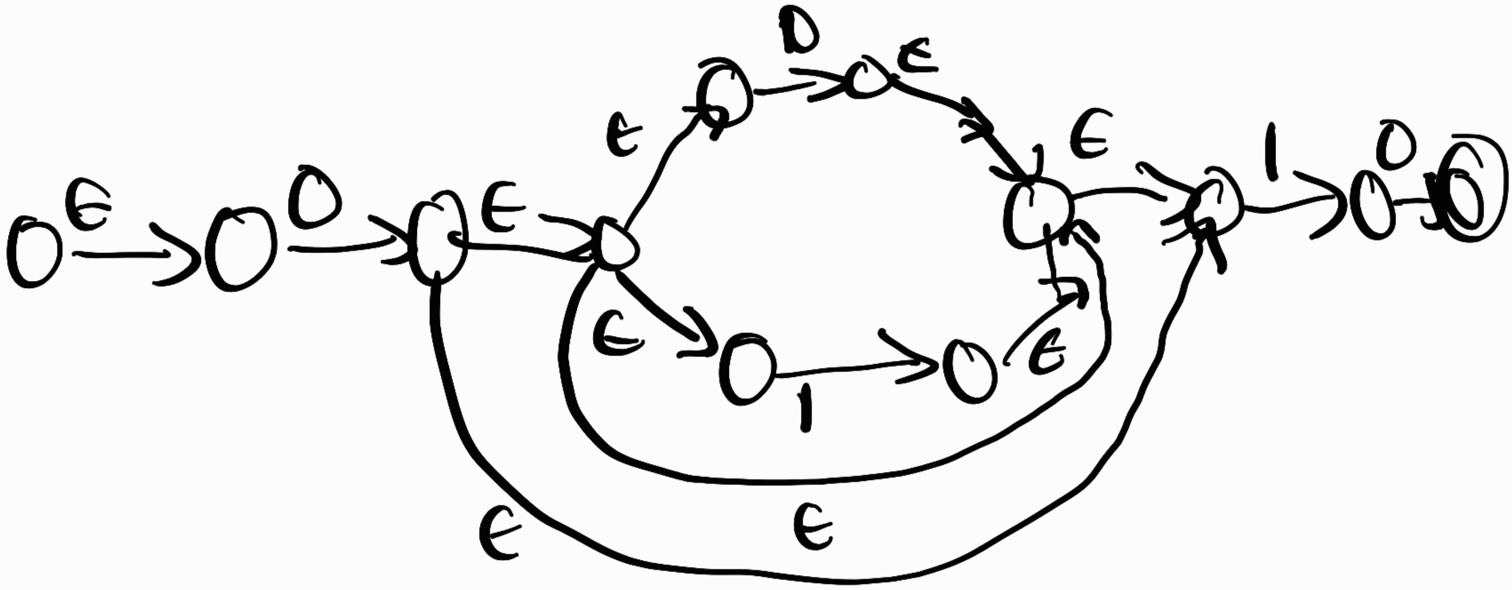
$r = (a+b)^*$



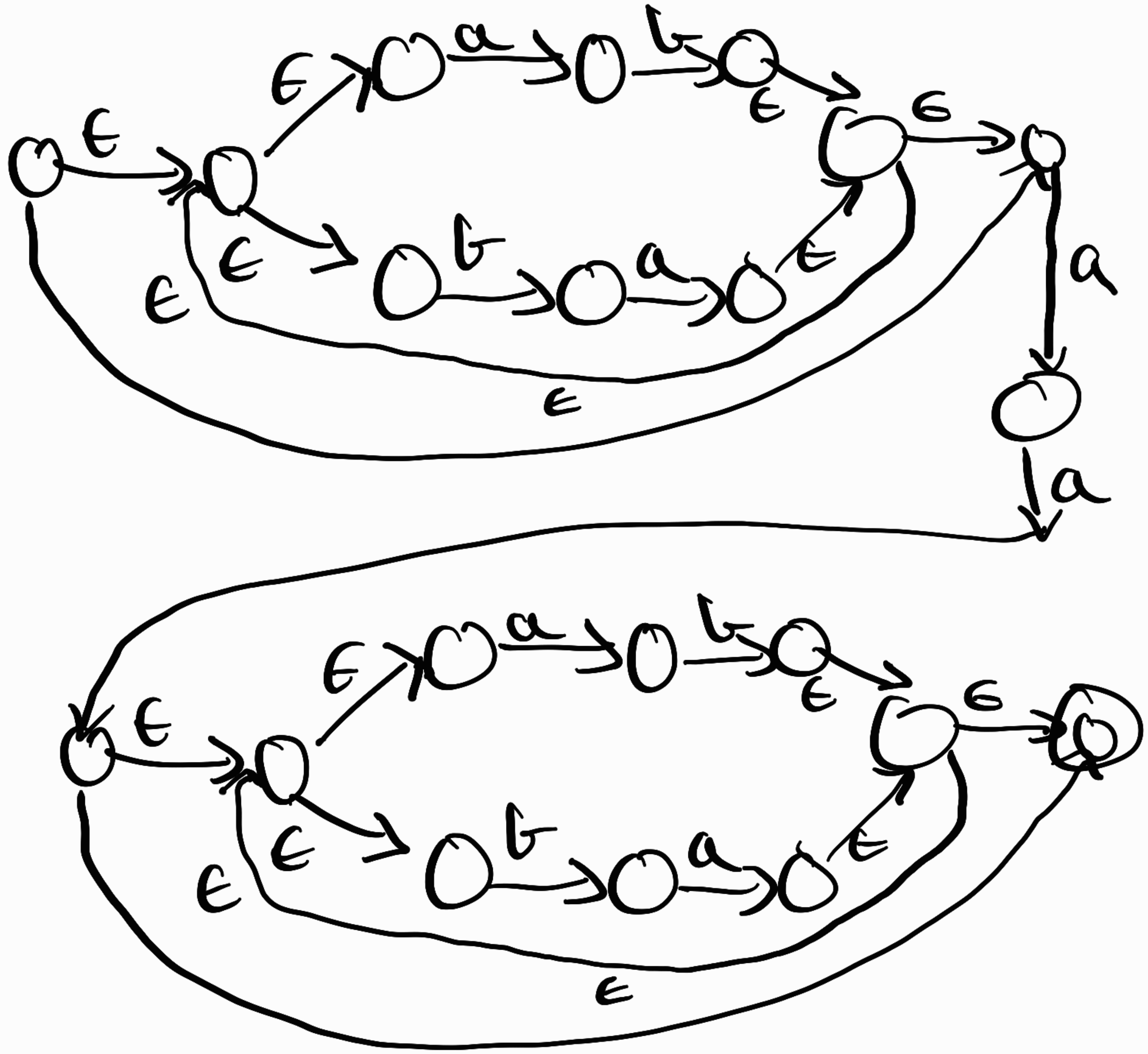
$r = b + ba^*$



$r = 0 \cdot (0+1)^* \cdot 1 \cdot 0$



$r = (ab + ba)^* \cdot aa\,(ab + ba)^*$



starting with ab

$ab(a+b)^*$

starts with b b a

$r = b \cdot b \cdot a \cdot (a+b)^*$

lang ends with abb

$r = (a+b)^* \cdot a \cdot b \cdot b$

lang string that contains aa

$(a+b)^* aab (a+b)^*$

---

starts and ends with a

$r = a \cdot (a+b)^* \cdot a + a$

starts and ends with same symbol

$$r = \left(a\cdot(a+b)^{*}\cdot a + a\right)$$

$$+ \left(b\cdot(a+b)^{*}b + b\right)$$

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

$$+b) + (a+b)$$

starts and ends with different symbol

$$r = (a \cdot (a+b)^* b) + (b \cdot (a+b)^* a)$$

$|w| = 3$ for strings

$$r = (a+b) \cdot (a+b) \cdot (a+b)$$

$|w| \geq 3$

$$r = (a+b) \cdot (a+b) \cdot (a+b) \cdot (a+b)^*$$

$|w| \geq 3$

$$r = (a+b) + (a+b)^2 + (a+b)^3 + \epsilon$$

$|w|_a = 2$

$|w|_a \geq 2$

$|w|_a \leq 2$

3rd symbol from the left is 'b'

28th symbol from right is 'a'