Formal Languages and Automata Theory
Exercises Finite Automata
Unit 3 – Part 3

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* Several exercises are based on the ones proposed in the following books:

- Enrique Alfonseca Cubero, Manuel Alfonseca Cubero, Roberto Moriyón Salomón. *Teoría de autómatas y lenguajes formales.* McGraw-Hill (2007).
- Manuel Alfonseca, Justo Sancho, Miguel Martínez Orga. *Teoría de lenguajes, gramáticas y autómatas.* Publicaciones R.A.E.C. (1997).
- Pedro Isasi, Paloma Martínez y Daniel Borrajo. *Lenguajes, Gramáticas y Autómatas. Un enfoque práctico.* Addison-Wesley (1997).

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1. Indicate the graph of a NFA, only including the number of indicated states, which recognizes each one of the following languages. The alphabet is always {0.1}.

    a) The language $0^m1^n0^p$ ($m \geq 0, n \geq 0, p \geq 1$) <u>with only 3 states</u>.

    b) The language {0} <u>with only 2 states</u>.

2. Given the language $(01)^n$ with $n \geq 0$, indicate which of the following finite automata generates this language. In addition, obtain the minimal equivalent DFA for the selected automaton.

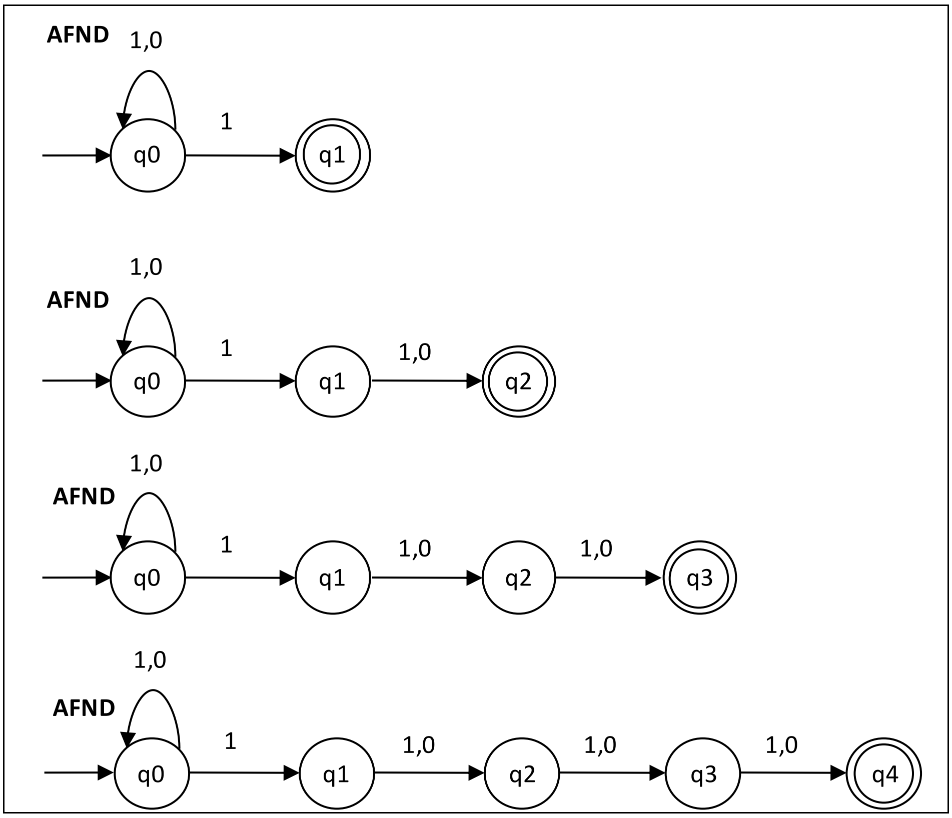
    a. FA=[{0,1}, {A,B,C,F}, f, A, {F}]
    f(A,0)=B, f(A, λ)= λ, f(C,0)=B, f(B,1)=C, f(B,1)=λ

    b. FA=[{0,1}, {A,B,C,F}, f, A, {F}]
    f(A,0)=B, f(A, λ)=F, f(C,0)=B, f(B,1)=C, f(B,1)=F

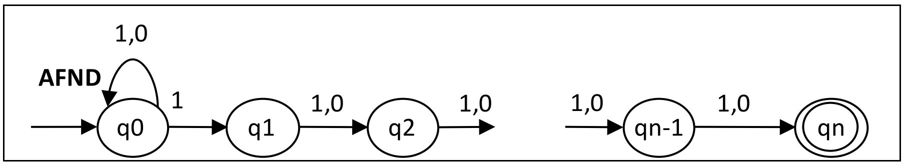
    c. FA=[{0,1}, {A,B,C,F}, f, A,{F}]
    f(A, B)=0, f(A,F)= λ, f(C,B)=0, f(B,C)=1, f(B,F)=1

    d. FA=[{0,1}, {A,B,C,F}, f, A, {F}]
    f(B,0)=A, f(F,λ)=A, f(B,0)=C, f(C,1)=B, f(F,1)=B

3. Indicate the graph of the DFA which corresponds to the NFAs indicated in the following figures.



How many states will the equivalent DFA to the following NFA have?



4. Obtain the minimal equivalent DFA for the following Non-Deterministic Finite Automata. Describe the intermediate transformations: NFA → DFA → Minimal DFA.

a)
NFA_A=({a,b,c},{Q0,Q1,Q2,Q3},f,Q0,Q3)

f(Q0, a) = Q1 ; f(Q0, b) = Q2 ; f(Q0, c) = Q3
f(Q1, a) = Q2 ; f(Q1, b) = Q3 ; f(Q1, c) = Q1
f(Q2, a) = Q3 ; f(Q2, b) = Q1 ; f(Q2, c) = Q3

b)
NFA_B=({a,b,c},{Q0,Q1,Q2,Q3,Q7},f,Q0,Q3)

f(Q0, a) = Q0,Q2,Q3 ; f(Q0, c) = Q1
f(Q1, c) = Q3 ;
f(Q2, b) = Q2,Q3
f(Q7, b) = Q2,Q3

c)
NFA_C=({a,b,c},{Q0,Q1,Q2,Q3,Q4,Q5},f,Q0,Q5)

f(Q0, a) = Q1 ; f(Q1, a) = Q1,Q5
f(Q1, b) = Q2 ; f(Q2, b) = Q2,Q3,Q5
f(Q3, b) = Q2,Q3 ; f(Q3, c) = Q4
f(Q4, b) = Q2,Q3 ; f(Q4, c) = Q3

d)
NFA_D=({c,f,d},{Q0,Q1,Q2,Q3,Q4,Q5,Q6},f,Q0,Q6)

f(Q0, c) = Q1,Q4 ; f(Q0, f) = Q2,Q6 ; f(Q1, c) = Q1
f(Q1, f) = Q3 ; f(Q1, d) = Q4 ; f(Q2, c) = Q0
f(Q3, c) = Q3 ; f(Q3, f) = Q3 ; f(Q4, c) = Q4
f(Q4, f) = Q5 ; f(Q4, d) = Q5 ; f(Q5, c) = Q5
f(Q5, f) = Q5

5. Draw the graph of a Determinist Finite Automaton. The alphabet is always {0, 1}. The problem can be solved by directly designing the DFA, or by starting from the NFAs obtained in problem 4.
   a) The language $0^m1^n0^p$ ($m \geq 0, n \geq 0, p \geq 1$) (the NFA included only three states)
   b) The language {0} (the NFA included only two states)

6. Given the NFA (with lambda transitions) described by the following table, obtain the minimal equivalent DFA.

	a	b	c	λ
→p	p	q		q
q	q	p,r		r
r			s	p
*** s**	s			

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7. Indicate the graph of the DFA corresponding to the following NFA: