جامعة المستقبل
AL MUSTAQBAL UNIVERSITY

قسم الامن السيبراني

DEPARTMENT OF CYBER SECURITY

SUBJECT: COMPUTATION THEORY
CLASS: 3rd

LECTURER: MSC :MUNTATHER AL-MUSSAWEE

LECTURE: (3)

THEORY OF AUTOMATA
FINITE AUTOMATA, DFA AND NFA

Lecture Three

Theory of Automata

What is Automata?

The term "Automata" is derived from the Greek word "αὐτόματα" which means "self-acting".

✍ "Automation" الأتمتة تدل على التنفيذ التلقائي لعمليات معينة وتوليد نتيجة لهذه العمليات.

An automaton with a finite number of states is called a ***Finite Automaton (FA)*** or ***Finite State Machine (FSM).***

✍ **Finite State Machine (FSM)** هي عبارة عن انموذج لجهاز احتسابي بسيط Device Computational تمتلك هذه الاجهزة حجما صغيرا″ جدا″ من الذاكرة و يعالج مدخلاته بصورة مباشرة نعني بهذا أن الجهاز يقرأ رمزا″ واحدا″ خلال وحدة الزمن ويقوم بمعالجته.

- There are two Type of Finite State Machine (FSM):
  1- Deterministic Finite Automaton(DFA)
  2- Non- deterministic Finite Automaton(NFA)

A finite automaton is a collection of three things:

1- A finite set of states, one of which is designated as the initial state, called the ***start state***, and some of which are designated as ***final states***.
2- An alphabet ∑ of possible input letters, from which are formed strings, that are to be read one letter at a time.
3- A finite set of ***transitions*** that tell for each state and for each letter of the input alphabet which state to go to next.

✍ 1- Start state denoted by  or 

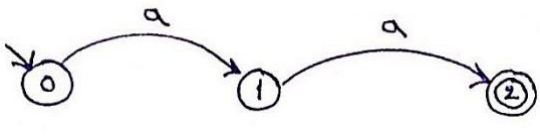
2- Final state denoted by  or  or 

3- There is one letter input per connection at a time.

Example: Draw Finite Automata (FA) transition diagram and transition table for

the following Regular Expressions (RE).

1- aa

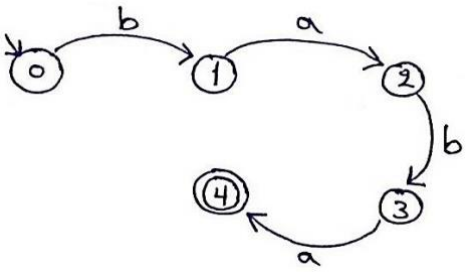


Transition diagram

Transition Table

	a
0	{1}
1	{2}
2	–

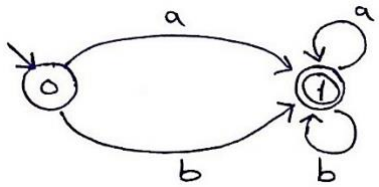
2- baba



Transition Table

	a	b
0	–	{1}
1	{2}	–
2	–	{3}
3	{4}	–
4	–	–

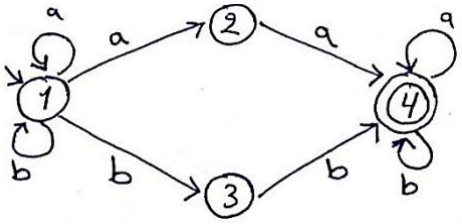
3- $(a + b)(a + b)^* \equiv (a + b)^+$



Transition Table

	a	b
0	{1}	{1}
1	{1}	{1}

4- $(a + b)^* (aa + bb) (a + b)^*$



Transition Table

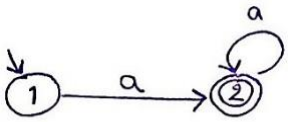
	a	b
1	{1, 2}	{1, 3}
2	{4}	–
3	–	{4}
4	{4}	{4}

5- $(a + b)^*$

Transition Table

	a	b
S	{S}	{S}

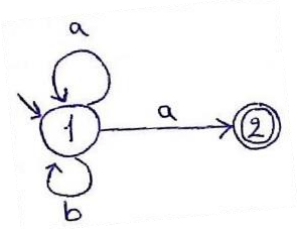
6- aa^*



Transition Table

	a
1	{2}
2	{2}

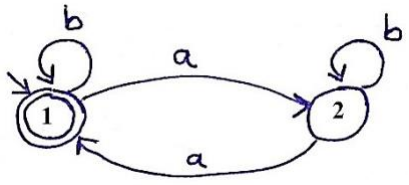
7- $(a + b)^*a$



Transition Table

	a	b
1	{1, 2}	{1}
2	–	–

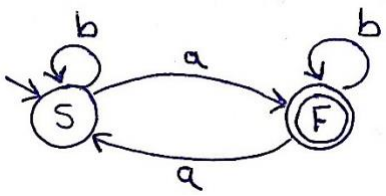
8- {a is even number}



Transition Table

	a	b
1	{2}	{1}
2	{1}	{2}

9- {a is odd number}



Transition Table

	a	b
S	{F}	{S}
F	{S}	{F}

Homework: Draw Finite Automata (FA) transition diagram for the following Regular Expressions (RE).

1- ∧
2- (a + b)*aa (a +b)*
3- a(aa)*
4- a(a + b)*a
5- (a + b)*abb

Deterministic Finite Automaton(DFA)

- DFA refers to deterministic finite automata. The finite automata are called deterministic finite automata if the machine is read an input string one symbol at a time.
- In DFA, there is only one path for specific input from the current state to the next state.
- DFA does not accept the null move, i.e., the DFA cannot change state without any input character.
- DFA can contain multiple final states. It is used in Lexical Analysis in Compiler.

Definition of a DFA

A DFA can be represented by:

1. A finite set of states.
2. A finite set of symbols called the alphabet (Σ).
3. The transition function.
4. The initial state from where any input is processed.
5. A final state/states.

Properties of DFA: There are two condition must be achieving **together**:

1. It has no transition on input ∧.
2. For each state (S) and input symbol (a) there almost one edge label (a) leave (S).

كل (FA) هو (DFA) لأن في كلاهما لايوجد (∧) ولايوجد اكثر من سهم اوحافة تخرج من نفس العقدة وتحمل نفس الحرف.

Nondeterministic Finite Automaton (NFA)

If the basic finite automata model is modified in such a way that from a state on an input symbol zero, one or more transitions are permitted, then the corresponding finite automata is called a "Nondeterministic finite automata" (NFA). Therefore, an NFA is finite automata in which there may exist more than one paths corresponding to x in $\sum^*$ (because zero, one, or more transitions are permitted from a state on an input symbol). Whereas in a DFA, there exists exactly one path corresponding to x in $\sum^*$.

A Nondeterministic finite automaton (NFA) is a collection of three things:

1. A finite set of states with one start state and some final states.
2. An alphabet $\sum$ of possible input letters.
3. A finite set of transitions that describe how to proceed from each state to other states along edges labeled with letters of the alphabet, where we allow the possibility of more than one edge with the same label from any state and some states for which certain input letters have no edge.

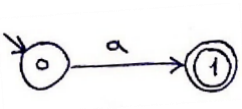
Properties of NFA: One or both of these conditions must be achieve:

1- It has transition on input ∧.

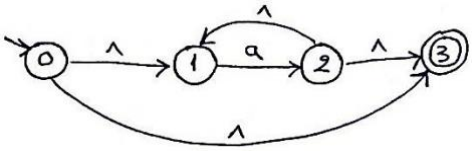
2- For each state (S) and input symbol (a) there almost more than one edge label (a) leave (S).

Example: Draw Nondeterministic finite automaton (NFA) transition diagram for the following Regular Expressions (RE).

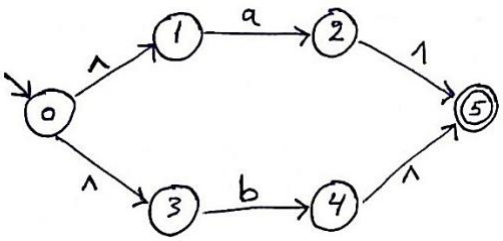
1- a



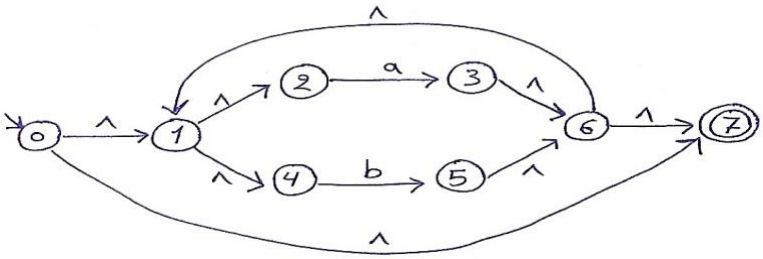
2- a*



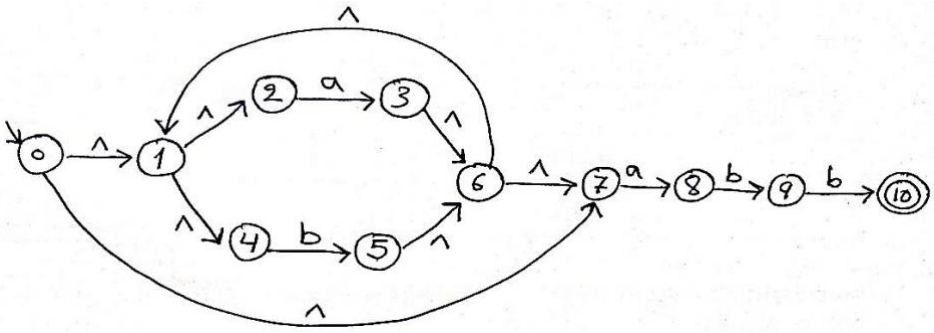
3- (a + b)



4- (a + b)*



5- (a + b)*abb



Homework: Draw Nondeterministic finite automaton (NFA) transition diagram for the following Regular Expressions (RE).

1- a(a +b)*a(a + b)
2- $(a + b)(a + b)^{+}$
3- (a +b)*b