National University of Computer & Emerging Sciences, Karachi

Spring-2025 CS-Department
Assignment 1

Issue Date: **Due date:**

Course Code: CS301	Course Name: Theory of Automata

Instructions:

- **This is hand written assignment.**
- **Write the correct question number with part number (e.g : Q1 part a).**
- **You can use A4 size paper for solving the assignment .**
- **Attempt all the parts of Question to get full marks.**
- **You must submit the your own handwritten assignment to your teacher with in the due date and a scanned copy of the assignment on google classroom within the due date, strong action would be taken on plagiarism cases from straight zero in assignment to Grade F in course.**

1. Determine whether the string 101011 is in each of the following languages with the help of DFA.

You must justify your answer by showing the transitions clearly with the input tape and pointer.

a) (0+1)*
b) 1*0+1+
c) 10(0+1)*11
d) (10+11)*001
e) 1(01+001)*(0+1)*
f) (101+0)*111

2. Construct regular expressions for the following languages.

a) Strings over Σ = {a, b} that do not contain "abb" as a substring.
b) Strings over Σ = {0,1} where every odd position contains '1'.
c) Strings that start and end with the same symbol over Σ = {x, y, z}.
d) Strings over Σ = {a, b, c} that have at most one 'c' and must contain at least two 'b's.
e) Strings over Σ = {0, 1} where the number of 1s is a multiple of 3.

3. Develop the NFA of your name using English alphabets. Now convert it into an equivalent DFA.

4. Convert the following regular expression to DFA :

a) (0+1)*101(0+1)*
b) 1(01+001)*0
c) (11+0)*(00+01)*
d) (a+b)*aab(a+b)*
e) (a+ab)*(ba+bb)*

f) j) (01+10+11)*00(0+1)*

5. You are given an ε-NFA with the following specifications:

Given ε-NFA:

- Alphabet (Σ): {0,1}
- States: {q0, q1, q2, q3}
- Start State: q0
- Final State: q3

Transition Table of ε-NFA:

Current state	input	Output
q0	ε	{q1,q2}
q1	0	{q3}
q2	1	{q3}
q3	0,1	{q3}

Task:

a) Compute the ε-closure for each state.

b) Construct the DFA transition table by converting the given ε-NFA.

c) Identify the start state and final states of the DFA.

d) Clearly show the step-by-step conversion process.

e) Draw the DFA state diagram.

Question 6: Union, Intersection, and Concatenation of DFAs. Given the following two DFAs:

Given the following two DFAs:

DFA 1:

- **States**: Q1={q0,q1}
- **Alphabet**: Σ={a,b}
- **Transition Function**:
    - δ1(q0,a)=q1
    - δ1(q0,b)=q0
    - δ1(q1,a)=q1
    - δ1(q1,b)=q1

- **Start State**: q0
- **Accept State**: q1

This DFA accepts strings containing at least one 'a'.

DFA 2:

- **States**: Q2={p0,p1}
- **Alphabet**: Σ={a,b}
- **Transition Function**:
    - δ2(p0,a)=p0
    - δ2(p0,b)=p1
    - δ2(p1,a)=p1
    - δ2(p1,b)=p1
- **Start State**: p0
- **Accept State**: p1

This DFA accepts strings containing at least one 'b'.

Tasks:

(a) **Union**: Construct a DFA that accepts the union of the languages recognized by DFA 1 and DFA 2 (i.e., strings containing at least one ‘a’ or at least one ‘b’).
(b) **Intersection:** Construct a DFA that accepts the intersection of the languages recognized by DFA 1 and DFA 2 (i.e., strings containing at least one ‘a’ and at least one ‘b’).
(c) **Concatenation:** Construct an NFA that accepts the concatenation of the languages recognized by DFA 1 and DFA 2.

Question 7: Complement & Reverse of DFA

Given the following DFA:

- States: Q={s0,s1}
- Alphabet: Σ={0,1}
- Transition Function:
    - δ(s0,0)=s1
    - δ(s0,1)=s0
    - δ(s1,0)=s1

- δ(s1,1)=s1

- Start State: s0
- Accept State: s1

This DFA accepts strings containing at least one '0'.

Tasks:

(a) **Complement:** Construct a DFA that accepts the complement of the language recognized by the given DFA.
(b) **Reversal:** Construct an NFA that accepts the reversal of the language recognized by the given DFA.

Question 8: Theory of Automata in Modern Search Engines

Many modern applications, such as search engines, chatbots, and spam filters, rely on automata-based models to process text efficiently. Regular expressions and finite automata play a crucial role in recognizing patterns in user queries and filtering relevant results.

Using your knowledge of DFA, NFA, and Regular Expressions, answer the following:

a) How can regular expressions and finite automata be used in search engines to match user queries with stored text?
b) If a chatbot is designed to recognize greetings like “Hello,” “Hi,” or “Hey,” but users may type variations like “Hii” or “Heey,” how could an NFA help recognize such variations?
c) Given what you have learned about DFA and NFA so far, what would be the advantages or disadvantages of using a DFA over an NFA in such systems?

Hint: Think about how search queries, autocomplete suggestions, and chatbot responses relate to pattern matching and state transitions in automata.