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National University of Computer and Emerging Sciences, Lahore Campus

Course Name:	Theory of Automata	Course Code:	CS-3005
Degree Program:	BS (CS)	Semester:	Fall 2023
Exam Duration:	60 Minutes	Total Marks:	30
Paper Date:	2-10-2023	Weight	17.5%
Section:	ALL	Page(s):	7
Exam Type:	Midterm-I		

Student : Name:_____ Roll No._____ Section:_____

Instruction/Notes: Answer in the space provided, showing complete working.
ROUGH SHEETS ARE NOT ALLOWED.
In case of confusion or ambiguity make a reasonable assumption.

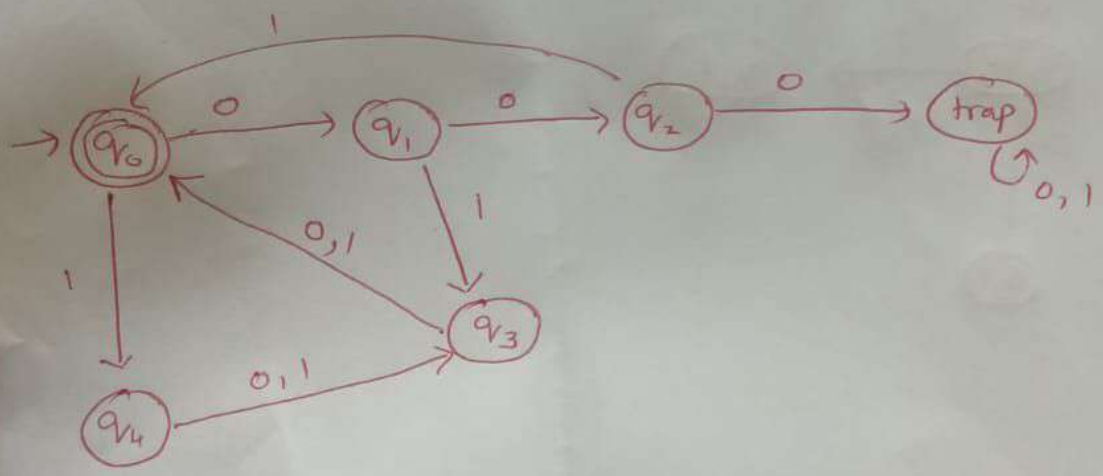
Good luck!

Question 1: (10 points):
Design deterministic finite automata (DFA) of the following language:

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

$L = \{x \mid x \in \sum^*$ and $|x|$ should be multiple of 3 and every three-length chunk of the string contains at most two occurrences of $0\}$

010 and 001100 are two of the accepting strings
0101 and 000010 are two of the rejecting strings



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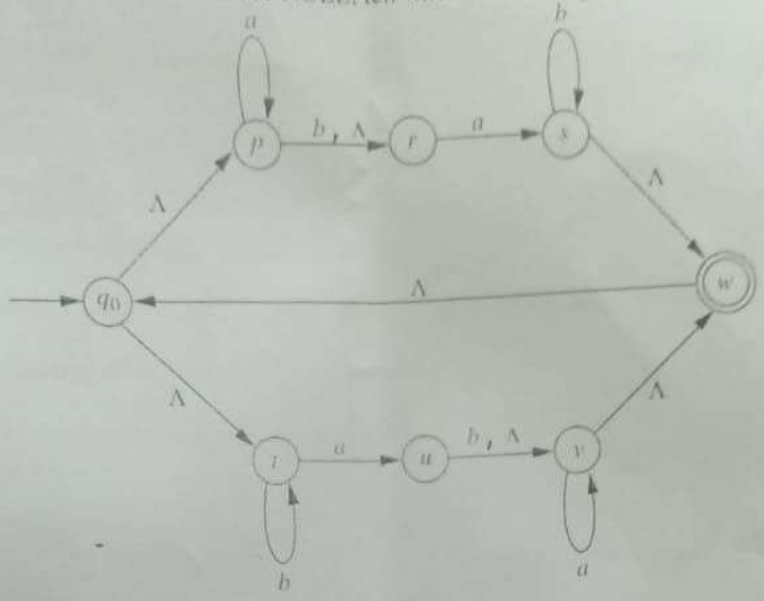
Question 2: (5 points):

Using the extended transition function for NFA-NULL, tell whether the string **ab** ∈ L or not. Show full working.



$\delta^*(q_0, ab)$

$= \Lambda\{ \bigcup_{r \in \delta^*(q_0, a)} \delta(r, b) \} \rightarrow (1)$

$\delta^*(q_0, a) = \Lambda\{ \bigcup_{p \in \delta^*(q_0, \Lambda)} \delta(p, a) \} \rightarrow (2)$

$\delta^*(q_0, \Lambda) = \Lambda\{q_0\}$

$= \{q_0, p, t, r\}$

Putting in (2)

$\delta^*(q_0, a) = \Lambda\{ \bigcup_{p \in \{q_0, p, t, r\}} \delta(p, a) \}$

$= \Lambda\{\phi \cup \{p\} \cup \{u\} \cup \{s\}\}$

$= \Lambda\{p, u, s\}$

$= \{p, r, u, v, w, q_0, p, t, r, s, w\}$

Putting in (1)

$\delta^*(q_0, ab) = \Lambda\{ \bigcup_{r \in \{p, r, u, v, w, q_0, t, s, w\}} \delta(r, b) \}$

$= \Lambda\{r, v, t, s\}$

$= \{r, v, w, q_0, p, t, s\}$

Since $w \in \Lambda$

so

$ab \in L$.

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Question 3 (5+2 +2+2+4 = 15 points): Short answers

PART A

Consider a language L defined over the alphabet set Σ. Suppose D_1 is a deterministic finite automata (DFA) with 5 tuples (Q,Σ, q_0, A, T) where

Q = finite set of states
Σ = finite set of alphabets
q_0 = initial state
A= set of final states
T= set of transition functions.

Construct finite automata F1 ((DFA or NFA or NFA-NULL but clearly mention which FA you have developed)) for L^R where

L^R = Reverse of L.

You have to define all the 5 tuples of F1 (Q_1,Σ_1, p_0, A_1, T_1)

Q_1 = { $Q \cup P_0$ }

Σ_1 = { Σ }

p_0= P_0

A_1 = { q_0 }

T_1= { $T_1(P_0, \Lambda) \rightarrow A$
invert all transition if $T(q,a) \rightarrow r$ in D_1 then for F1 $T_1(r, a) \rightarrow q$ }

FA = NFA -Λ.

Hint:
Construct FA for L^R and then fill the tuples.
If L accepts the string $x= x_0 x_1 \ldots x_n$ { where $x_0 x_1 \ldots x_n \varepsilon \Sigma$) then L^R will accept $y= x_n x_{n-1} \ldots x_1 x_0$.
For example

Example #1
$L= \{x | x \varepsilon \{a,b\}^*$ and x = abbb$\}$

Then
$L^R = \{x | x \varepsilon \{a,b\}^*$ and x= bbba$\}$

Example #2
$L= \{x | x \varepsilon \{a,b\}^*$ and x ends with ab$\}$

Then
$L^R = \{x | x \varepsilon \{a,b\}^*$ and x starts with ba$\}$

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PART B

True/ False with justification (no marks without justification)

Every DFA is also a NFA-NULL

True

In NFA-NULL transition function is defined as $Q \times \{\Sigma \cup \Lambda\} \to 2^Q$

DFA : $Q \times \Sigma \to Q$ & $Q \in 2^Q$. It is not necessary to have a Null-transition for every state

PART C

Language is regular if it has FA and R.E.

PART D

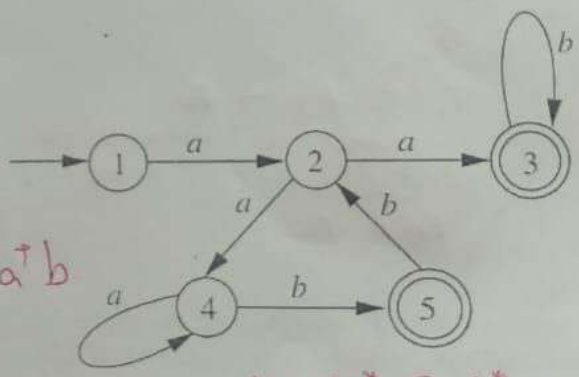
Give regular expression for the following language.

L= {x| x ε{a,b}* and x starts with ab and ends with ba}

Ans: $ab(a+b)^*ba + aba$ (1) (1)

PART E

NFA for the Language L is given below.



a) Write regular expression for the language accepted by this FA? [Hint: No need to apply state elimination method]

$a(a^+bb)^*ab^* + a(a^+bb)^*aa^+b$ (1) (1)

$a(a^+bb)^*[ab^* + aa^+b]$

b) Enumerate the language L' (complement of L) [at least 10 elements in increasing order of length]

→ Λ
→ $ab^+(a+b)^*$
→ $b^+(a+b)^*$
→ $aaa^+ + a$

{ Λ, a, b, ba, ab, bb, aaa, aba, abb, bab, bbb, ... }