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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.

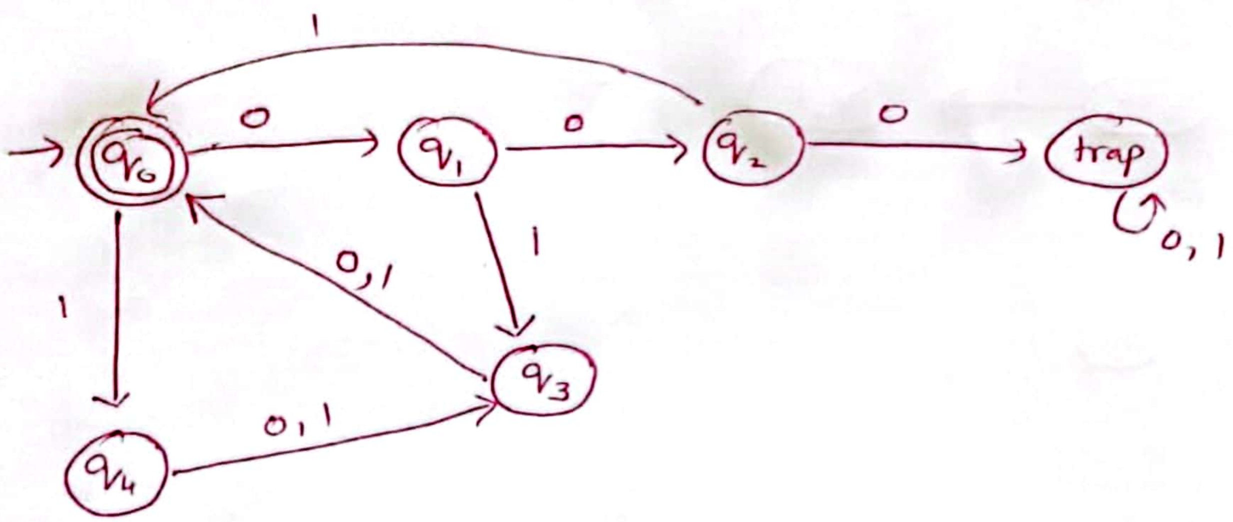
Good luck!

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

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

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

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



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Question 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 $x= x_0\ x_1 \dots x_n$ { where $x_0\ x_1 \dots x_n \varepsilon\ \Sigma$) then L^R will accept $y= x_n\ x_{n-1} \dots x_1\ x_0$

For example

Example #1

L= {x| x ε {a,b}* and x = abbb}

Then

L^R = {x| x ε {a,b}* and x= bbba}

Example #2

L= {x| x ε {a,b}* and x ends with ab}

Then

L^R = {x| x ε {a,b}* and x starts with ba}

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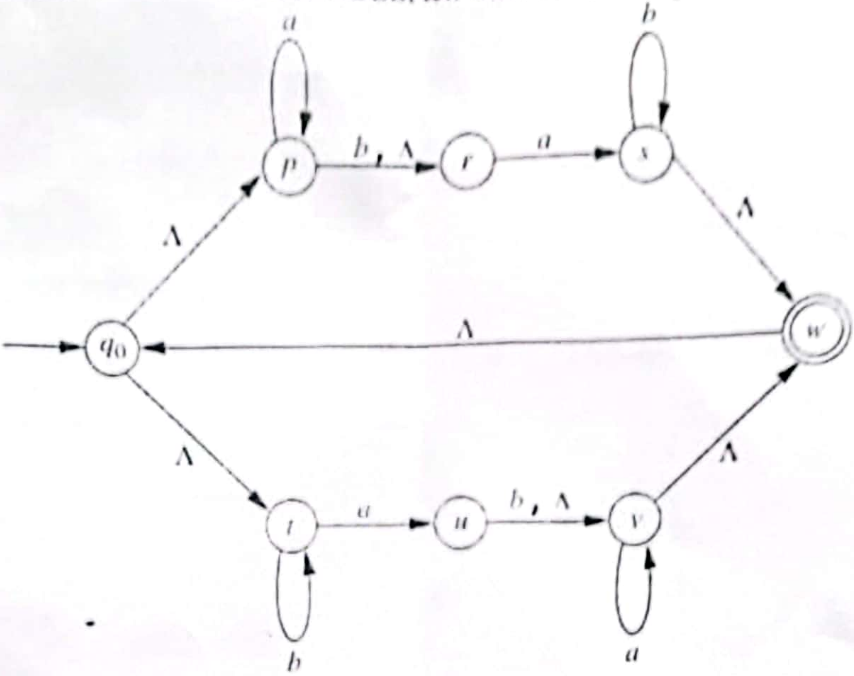
Question 2: (5 points):

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



$\delta^*(q_0, ab)$

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

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

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

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

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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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.

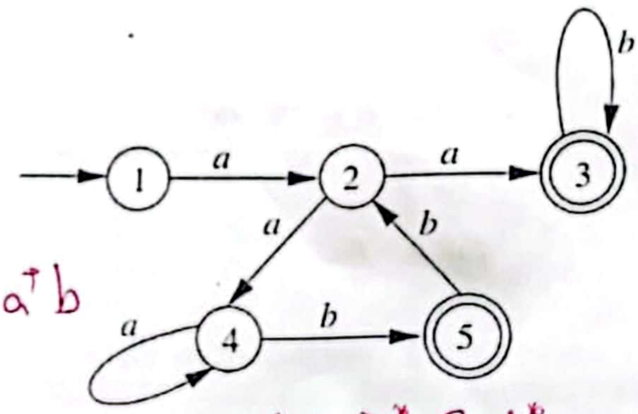
L= {x| x ε{a,b}* and x starts with ab and ends with ba}

Ans: $\underbrace{ab(a+b)^*ba}_{1} + \underbrace{aba}_{1}$

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]



$\underbrace{a\,(a^+bb)^*ab^*}_{1} + \underbrace{a(a^+bb)^*}_{1}aa^+b$

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

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, ... }

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