National University of Computer and Emerging Sciences, Lahore Campus

Course:	Theory of Automata	Course Code:	CS-3005
Program:	BS (Computer Science)	Semester:	Fall 2021
Duration:	180 minutes	Total Marks:	75
Paper Date:	21st Jan 2022	Page(s):	10
Section:	ALL	Section:	
Exam:	Final Exam	Roll No:	

Instruction/Notes: Answer in the space provided, showing all the working
NO ROUGH SHEETS
In case of any confusion or ambiguity make a reasonable assumption. Good luck!

Question 1: Prove that the language L is non-regular using the **pumping lemma for regular languages**. Your solutions should clearly show a string, length of string, all the possible divisions of the strings, and contradiction for all the divisions **(10 points)**

$L = \{www \mid w \in \{0,1\}^*\}$

Suppose L is RL with pumping length p.

$s = 0^p 1 0^p 1 0^p 1 \quad |s| > p.$

possible divisions to uvw s.t. $v \neq \wedge$ & $|uv| \leq p$

v will get one or more zeros from first 0^p.

$\underbrace{0^{p-n-m}}_{u} \underbrace{0^n}_{v} \underbrace{0^m 1 0^p 1 0^p 1}_{w}$.

where $n > 0$

for $i = 0 \quad uv^0w = 0^{p-n} 1 0^p 1 0^p 1 \notin L$

therefore $L \in RL$.

- marks deducted if value of p is assumed.
- if division not done s.t. $|uv| \leq p$.

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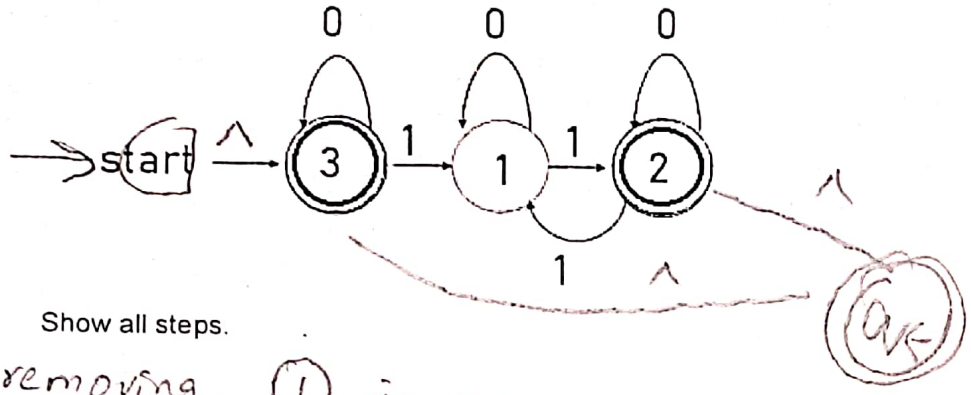
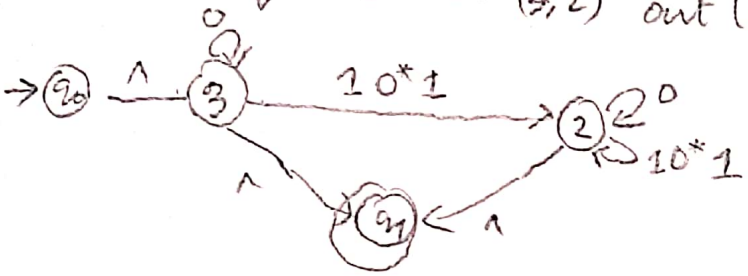
Question 2: Convert the following FA to RE using the **state elimination method**. Eliminate the states in the given order: 1, 2 and then 3. **(10 points)**

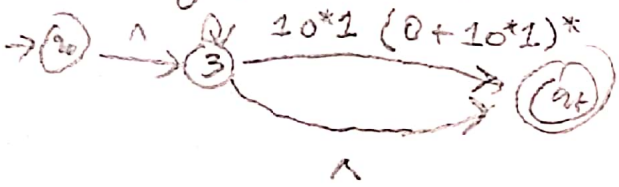


Show all steps.

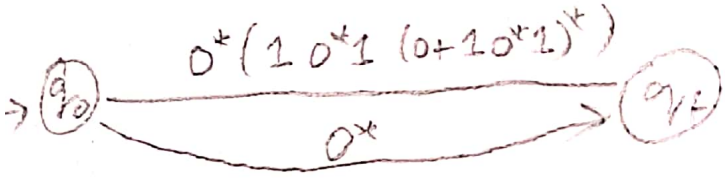
removing (1) in (3, 2) out (2)



removing (2) in (3) out (2)



removing (3) in q_0 out q_f



The RE given in this box will only be marked

$0^* + 0^*(10^*1(0+10^*1)^*)$.

$0^*(\lambda + 10^*1(10^*+0)^*)$

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Question 3: You have a multi-tape Turing machine (MTM) that has 4 tapes T1, T2, T3, and T4. Initially, T1, T2 and T3 contain one word/string each, while T4 is empty. Design a MTM that concatenates the words *w1*, *w2* and w3 on tapes T1, T2 and T3 respectively, and store the resulting word on T4 in the form Δ*w1#w2#w3#*. Input alphabet set = Σ = {a,b}. All tapes heads are initially at the leftmost slot. Consider the sample example:

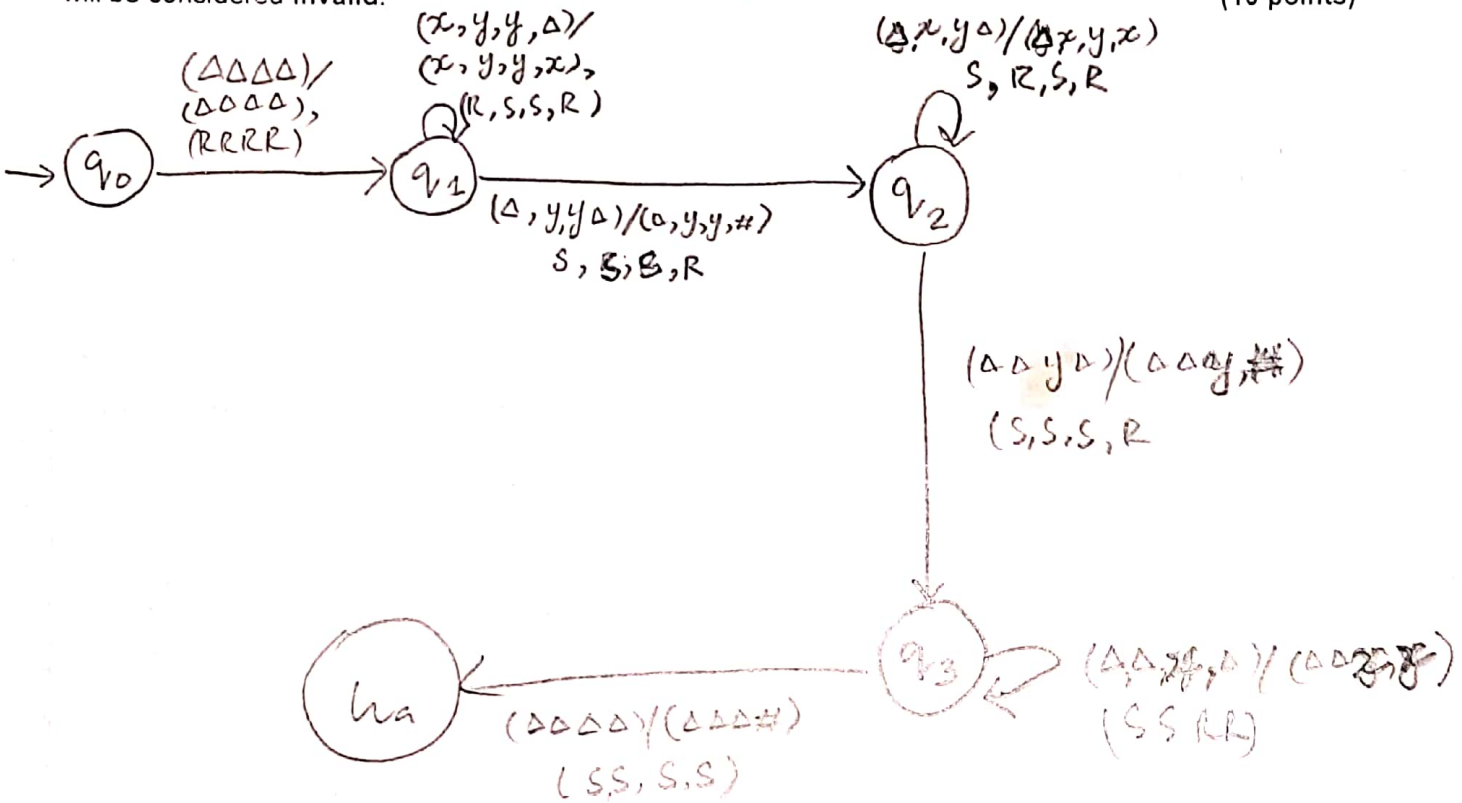
Input:

T1	Δ	a	b	Δ		
T2	Δ	b	b	a	Δ	
T3	Δ	b	Δ			
T4	Δ	Δ	Δ	Δ	Δ	Δ

Output:

T4	Δ	a	b	#	b	b	a	#	b	#

You must use as few states as possible. An MTM with more than 5 states **including** the start and final states will be considered **invalid**. **(10 points)**



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Question 4: Convert the following CFG to CNF. Neatly write the final CFG in the table below. (10 points)

S-> ABA | C | Cb
A-> λ
B->ab
C->B | λ
D->a
Note: λ represents null
Show all steps:

Step 1:- Remove $A \to \lambda$

$S \to ABA \mid C \mid Cb$ (not adding AB, BA as A only goes to Null)

A

$B \to ab$

$C \to B \mid \lambda$

$D \to a$

Remove $C \to \lambda$.

$S \to B \mid \lambda \mid Cb \mid b$

$B \to ab$

$C \to B$

$D \to a$

Step 2 Remove unit Productions -

$S \to ab \mid \lambda \mid Cb \mid b$

~~$B \to ab$~~ (use less now)

$C \to ab$

$D \to a$

Step 3:- Remove . two terminals & terminal & variable

$S \to X_aX_b \mid \lambda \mid CX_b \mid b$

$C \to X_aX_b$.

$X_a \to a$ $X_b \to b$.

The Final CFG given in this box will only be marked

$S \to X_aX_b \mid CX_b \mid b \mid \lambda$

$C \to X_aX_b$

$X_a \to a$

$X_b \to b$.

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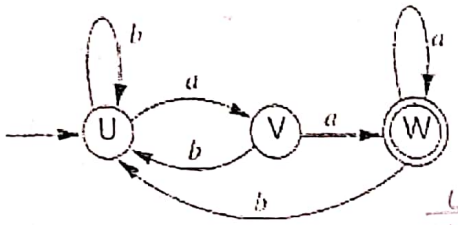
Question 5: Given D1 and D2, determine DFA of L(D1) - L(D2)' using the proofs of closure properties. For credit, provide the final DFA in the box given on the next page. **(10 points)**

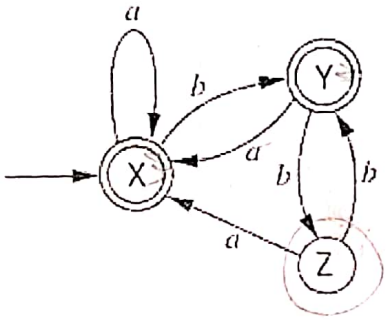
Note: ' is complement

D1:



	a	b
U	V	U
V	W	U
W	W	U

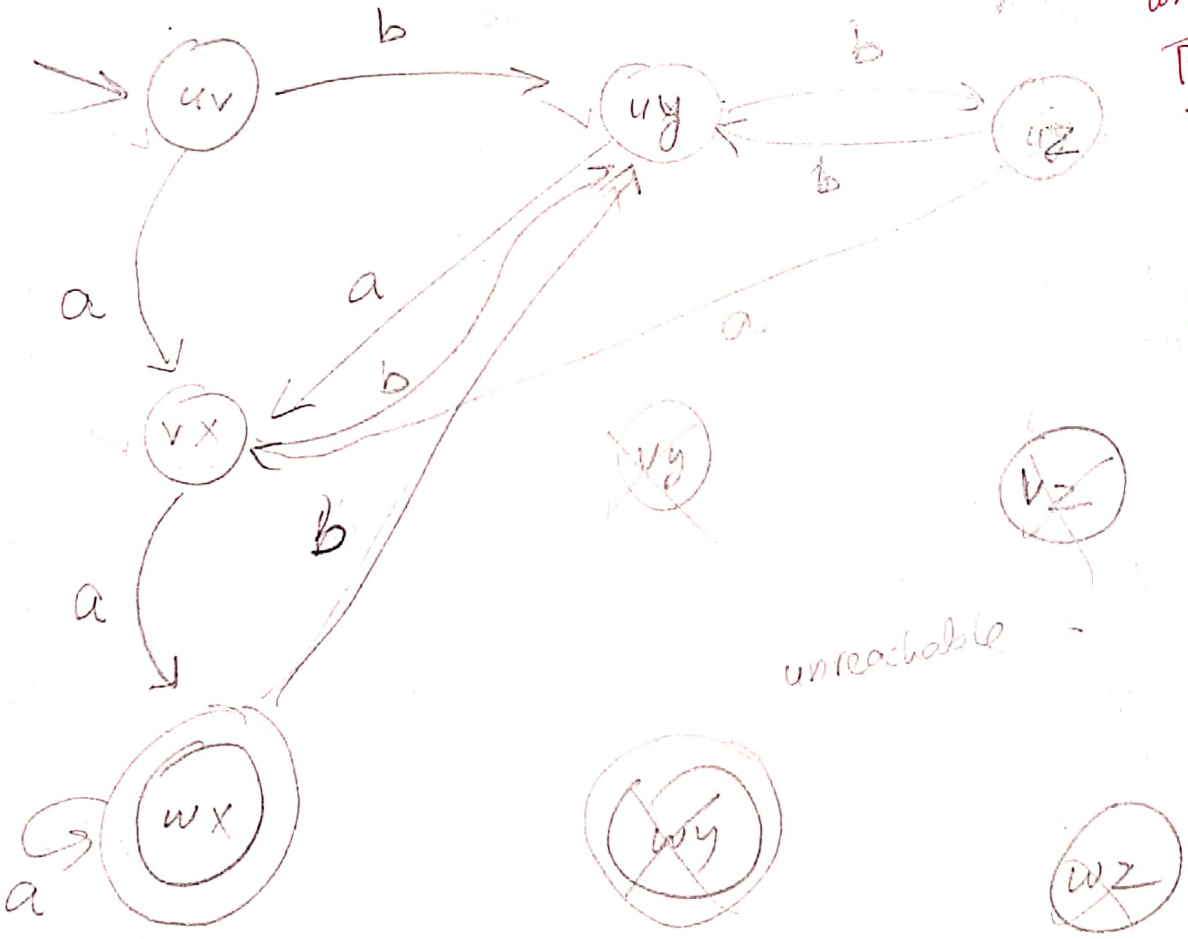
D2: D2'



	a	b
x	x	y
y	x	z
z	x	y

Show all steps.

has to be done using closure properties. otherwise 0 marks.



D_2' 2 points. rest is for $D_1 - D_2'$

unreachable

final states are final of D1 {w}

Eg non final of D_2' {x, y}

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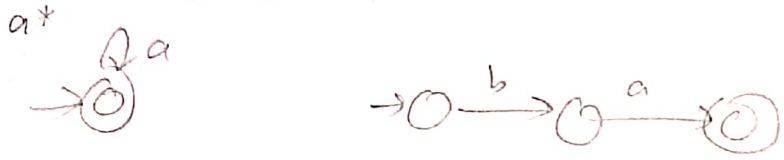
Question 6: Short questions:

a: What is the use of Pumping Lemma for CFL, write a 1-line answer **(3 points)**

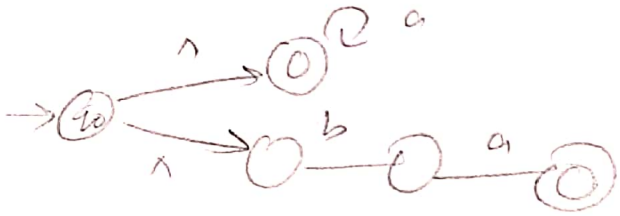
To prove show that a language is non CFL

b: Convert the following RE to NFA-null. Show all steps **(5 points)**

a*+ba



a* + ba



c: Given a CFG write in one line what is the language of this CFG. **(5 points)**

Note: λ represents null.

S → Aa | MS | SMA
A → Aa | λ
M → λ | MM | bMa | aMb

Strings with $n_a > n_b$

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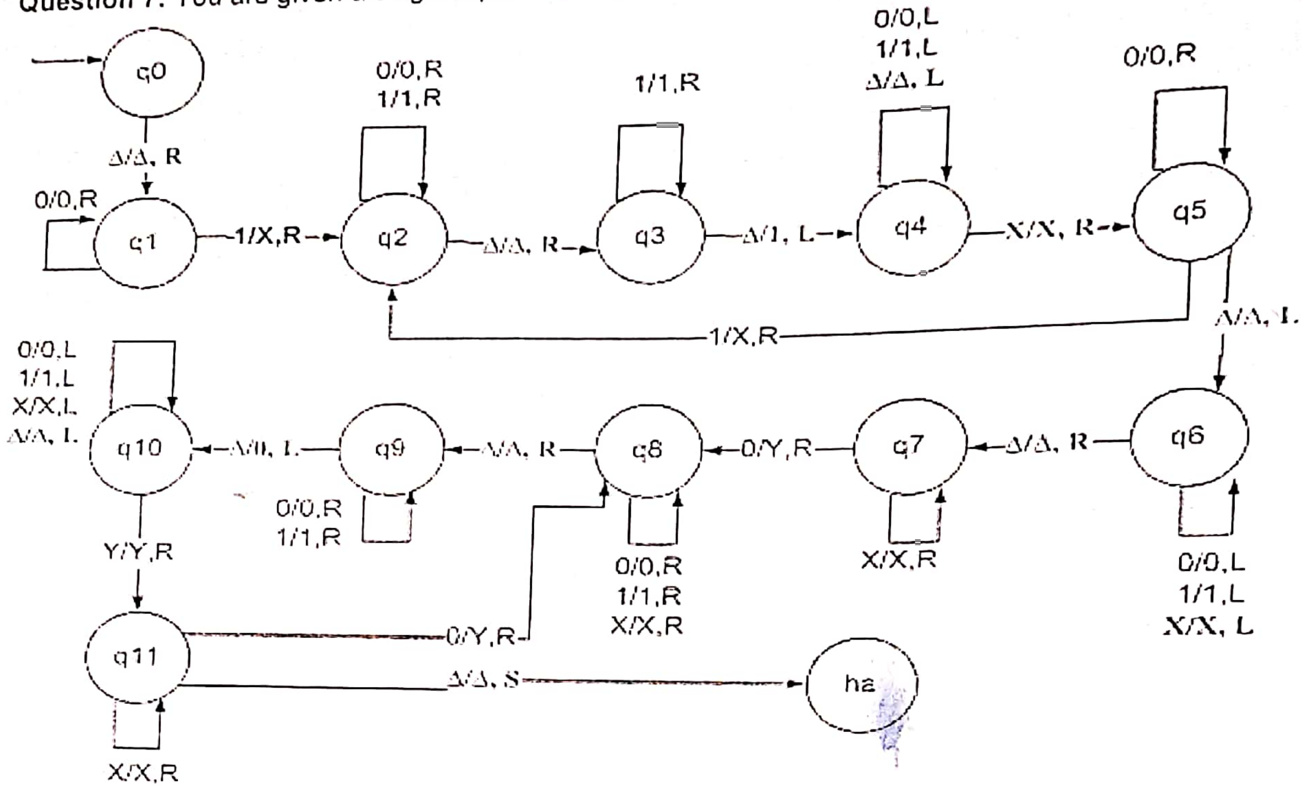
Question 7: You are given a single tape TM. The state q0 is the start state.



You have to run the TM on the string 11010101 and determine the configuration of the resulting tape? (Show working)

(12 points)

Tape you are given:

Δ	1	1	0	1	0	1	0	1	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	...

Tapes for rough work:

Δ																				
Δ																				
Δ																				
Δ																				
Δ																				
Δ																				

Resulting tape:

Δ	X	X	Y	X	Y	X	Y	X	Δ	1	1	1	1	1	0	0	0	Δ	Δ	Δ

Description of TM: Briefly explain in 1 sentence what is the TM doing (answer should be generic).

Writes sorted string after input in desc order

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