National University of Computer and Emerging Sciences
Lahore Campus

Theory of Automata (CS3005)   Final- Exam

Date: Dec 31st 2024

Course Instructor(s)

Dr. Sobia Tariq Javed
Dr. Tahir Ejaz
Mr. Hamad ul Qudous
Mr. Fraz Yousaf

Total Time (Hrs):	3
Total Marks:	80
Total Questions:	4

_____   _____   _____

Roll No   Section   Student Signature

Do not write below this line

- Attempt all the questions. No marks without working.
- In case of confusion or ambiguity make a reasonable assumption.
- Solve Q3, Q4 and Q5 on the question paper. Show working on the answer sheet (MUST).
- Provide only one final solution to each question. Submitting multiple solutions will result in cancellation, and no marks will be awarded. *Attach question paper with answer book.*

CLO	1	2		3	4		Total
Question#	Q1	Q3(a)	Q3(b)	Q4	Q2	Q5	
Marks (total)	10	10	10	10	20	20	80
Marks (obtained)							

CLO #1: Identify formal language classes and prove language membership properties.

Question#1 : Pumping Lemma   [marks 10]

Tell whether the following Language is context-free (CFL) or non- context-free (non- CFL). If it is CFL provide PDA else prove it using Pumping Lemma.

$$L = \{a^{2^k} \mid k \geq 0\}$$

CLO #4: Differentiate and manipulate formal descriptions of languages, automata, and grammars with a focus on non-context-free languages using Turing Machines

Question #2: Multi-tape TM: String Left Rotation Check   [marks 20]
Design a deterministic 2-tape TM to check if one string Y is a left rotation of another string X. You can assume X is on tape 1 and Y is on tape 2.

For example, "waterbottle" is a rotation of "erbottlewat". X = waterbottle and Y = erbottlewat
For your simplicity, we have reduced the input alphabet set to Σ= {a, b}

National University of Computer and Emerging Sciences
Lahore Campus

Accepting examples

Example # 1

Δ	a	b	b	a	b	Δ
Δ	b	b	a	b	a	Δ

Example # 2

Δ	a	b	b	a	b	Δ
Δ	a	b	a	b	b	Δ

Non-accepting examples

Example # 3

Δ	a	b	b	a	b	Δ
Δ	b	b	a	b	b	Δ

Example # 4

| Δ	a	b	b	a	b	Δ
Δ	a	b	a	a	b	Δ

CLO #2: Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on non-regular and regular using automata (DFA, NFA, NFA-Null)

Question#3 (a): NFA-NULL to NFA Conversion   [marks 10]

Convert the following **NFA-NULL** into an equivalent **NFA** by eliminating all Null transitions. Show your work step-by-step (on the answer sheet), including the computation of Null-closures for each state and the new transition table for NFA (fill in the table on the question paper).
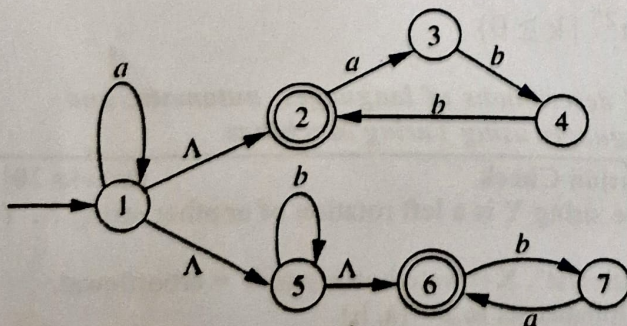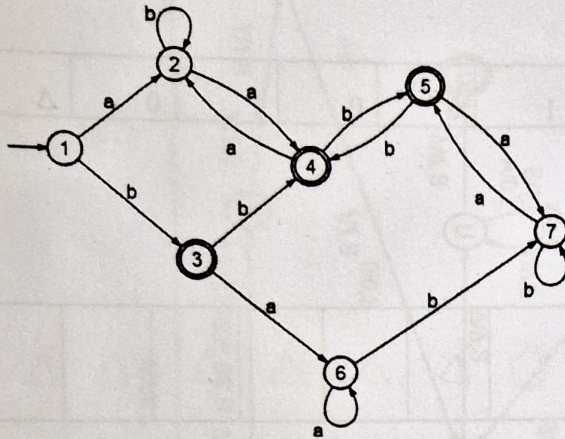
States q	δ (q,a)	δ (q,a)
1		
2		
3		
4		
5		
6		
7		

Question#3 (b): Minimization of DFA [marks 10]

Find a minimum-state DFA recognizing the same language. Show complete working. Use only the method discussed in your respective class. Show working on answer booklet.

Minimized DFA

CLO #3: Differentiate and manipulate formal descriptions of languages, automata, and grammar. with a focus on context-free languages using automata (PDA and NPDA).

Question#4: CYK [marks 10]

For the following grammar, use the CYK algorithm to determine whether the string **"abccba"** is in the language of the grammar.

S→ AB | BB
A→ BA | c | b | CC
B→ BB | a | b | c
C→ AA

Circle the correct option:

(Acceptable) / Unacceptable

National University of Computer and Emerging Sciences
Lahore Campus

CLO #4: Differentiate and manipulate formal descriptions of languages, automata, and grammars with a focus on non-context-free languages using Turing Machines

Question#5: Dry Run Turing Machine [marks 20]

Perform a dry run of the single-tape Turing machine on the next page and provide the tape's final content after the machine halts. Additionally, describe the machine's function or purpose.

The initial configuration of the TM is given below.

$	0	0	1	Δ	0	0	1	0	0	1	0	Δ

⬆ head/pointer

Final tape's content:

$	0	0	1	Δ	0	0	1	0	Δ	Δ	Δ	Δ	Δ	Δ

↑

Also mark where will be the head pointer.

Working (be brief and to the point)