جامعة القاهرة
CAIRO UNIVERSITY

كلية الحاسبات والذكاء الاصطناعي
جامعة القاهرة

Bar Code

إسم الطالب

رقم الطالب

Faculty of Computing and Artificial Intelligence
Cairo University

Final Exam

Program: **Computer Science / Software Engineering**
Course Name: **Theory of Computation**
Course Code: **CS432 / SCS432**
Instructor: **Dr. Amin Allam**
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Duration: **2 hours**

تعليمات هامة:

• حيازة التليفون المحمول مفتوحا داخل لجنة الأمتحان يعتبر حالة غش تستوجب العقاب وإذا كان الدخول بالمحمول ضروريا فيوضع مغلقا فى الحقائب .
• لا يسمح بدخول سماعة الأذن أو البلوتوث . • لا يسمح بدخول أي كتب أو ملازم أو أوراق داخل اللجنة ويعتبر مخالفة ذلك حالة غش .

60	

Question	Mark	Signature
One		
Two		
Three		
Four		
Five		
Six		
Seven		
Total Marks		

Total Marks in Writing: .....

- Use a pen or a dark-writing pencil to write clear answers.
- Write all intermediate steps of all your answers.
- It is not allowed to ask questions or to use additional papers.

Question 1 [8 Marks]

$\Rightarrow$ Convert the following Context-Free Grammar (CFG) to a Push-Down Autoamton (PDA) accepting by empty stack: $\mathbf{S} \rightarrow \mathbf{abSc}|\mathbf{c}$. Draw the resulting PDA, then fill in the following table where each row describes one PDA transition.

Current state	Input symbol	Stack top symbol	Operation	Next state

Question 2 [8 Marks]

$\Rightarrow$ A Mealy Machine is a Deterministic Finite Automaton (DFA) that outputs 0 or 1 with each transition. Draw a Mealy Machine that outputs $\mathbf{1}$ after each occurrence of "$\mathbf{abbab}$" (including overlapping occurrences) of any input string over the alphabet $\{\mathbf{a}, \mathbf{b}\}$. The machine must have exactly $\mathbf{5}$ states. Then, fill in the following table where each row describes one transition of the Mealy Machine.

Current state	Input symbol	Output	Next state

Question 3 [8 Marks]

$\Rightarrow$ Convert the following Non-deterministic Finite Automaton (NFA) to a Regular Expression by first deleting state $\mathbf{2}$ and then deleting state $\mathbf{1}$. Assume that the first step in the conversion is deleting state $\mathbf{2}$. Thus, do not add new start state or new accepting state. The start state is $\mathbf{0}$ and the accepting state is $\mathbf{3}$. The NFA consists of the transitions:
$\mathbf{T(0, a) = 1}$, $\mathbf{T(1, a) = 2}$, $\mathbf{T(1, b) = 1}$, $\mathbf{T(2, a) = 2}$, $\mathbf{T(2, b) = 1}$. $\mathbf{T(2, b) = 3}$.
Write the intermediate-steps computations and draw the intermediate-steps machines, then fill in the following tables, where each row describes one transition of the intermediate-steps machines.

The machine after deleting state $\mathbf{2}$ is:

Current state	Regular Expression	Regular Expression (Simplified)	Next state

The machine after deleting state $\mathbf{2}$ and then deleting state $\mathbf{1}$ is:

Current state	Regular Expression	Regular Expression (Simplified)	Next state

Question 4 [8 Marks]

$\Rightarrow$ Use the Second Pumping Lemma to prove that $(\mathbf{ab})^{\mathbf{n}}\mathbf{b}^{\mathbf{k}}\mathbf{a}^{\mathbf{t}}$ where $\mathbf{t} \geq \mathbf{0}$, $\mathbf{k} \geq \mathbf{0}$, and $\mathbf{n} > \mathbf{t}$ is not a Regular Language. Fill in the following tables which describe the main steps of the proof.

$\mathbf{xyz} =$

The following cases exist (Write all possible cases):

y	k	Resulting string	Why not belonging to the language?

Question 5 [8 Marks]

$\Rightarrow$ Find all Right Sentential Forms that can occur in a rightmost derivation of the following grammar: $\mathbf{S} \rightarrow \mathbf{aAc}, \mathbf{A} \rightarrow \mathbf{Ab}|\mathbf{b}$. For each Right Sentential Form, write its Handle and Lookahead in the following table.

Right Sentential Form	Handle	Lookahead

Question 6 [10 Marks]

$\Rightarrow$ Convert the following Push-Down Autoamton (PDA) accepting by empty stack, to a Context-Free Grammar (CFG). Write intermediate conversion steps. The PDA has starting state $\mathbf{0}$ and initial stack symbol $\mathbf{X}$ and consists of the transitions: $< \mathbf{0}, \mathbf{a}, \mathbf{X}, \mathbf{push}(\mathbf{X}), \mathbf{0} >$, $< \mathbf{0}, \mathbf{b}, \mathbf{X}, \mathbf{pop}, \mathbf{1} >$, $< \mathbf{1}, \mathbf{b}, \mathbf{X}, \mathbf{pop}, \mathbf{1} >$. Fill in the following table where each row describes the left-hand side (LHS) and right-hand side (RHS) of one CFG rule. Do not use the "|" symbol. Thus, consider the rule $\mathbf{A} \rightarrow \mathbf{x}|\mathbf{y}$ as two rules whose LHS is $\mathbf{A}$ and RHSs are $\mathbf{x}$ and $\mathbf{y}$. Write all resulting rules including the deleted ones, then for each rule: write in the last column the symbol ✘ if the rule is deleted or the symbol ✔ otherwise.

LHS	RHS	Preserved or deleted

Question 7 [10 Marks]

$\Rightarrow$ A Linear-Bounded Automaton (LBA) is a Turing Machine restricted to a finite tape consisting of the input tape cells together with two boundary cells that may not be changed. Draw a Deterministic LBA that accepts $\mathbf{a^n b^{n+1}}$ where $\mathbf{n \geq 0}$ given input string over the alphabet $\{\mathbf{a}, \mathbf{b}\}$. Then, fill in the following table which describes the meaning and action of each state (what the state does in English). Also, fill in the table where each row describes one transition of the Deterministic LBA.

State	Meaning and Action

Current state	Read symbol	Write symbol	Move direction	Next state