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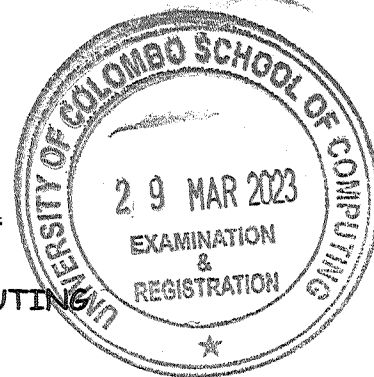
UNIVERSITY OF COLOMBO, SRI LANKA**UNIVERSITY OF COLOMBO SCHOOL OF COMPUTING****BACHELOR OF SCIENCE IN COMPUTER SCIENCE**

Second Year Examination - Semester II - UCSC AY19 [held in March 2023]

SCS 2212 – Automata Theory***TWO (2) HOURS*****Answer ALL questions**

Number of Pages = 13

Number of Questions = 4



To be completed by the candidate

Index Number:

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Important Instructions to candidates:

- I. Students should answer in the medium of English language only using the space provided in this question paper
- II. Note that questions appear on both sides of the paper. If a page or a part of this question paper is not printed, please inform the supervisor immediately.
- III. Write your index number CLEARLY on each and every page of the Question paper.
- IV. This paper consists of 4 questions in 13 pages (including the Cover Page).
- V. Answer ALL questions.
- VI. Calculators and any electronic device capable of storing and retrieving text including electronic dictionaries, smart watches and mobile phones are NOT ALLOWED.
- VII. Do not tear off any part of this answer book. Under no circumstances may this book, used or unused, be removed from the Examination Hall by a candidate.

To be completed by the examiners

Question No	Marks
1	
2	
3	
4	
Total	

Index No:

Question 1

(a) State the formal 5-tuple description of a Deterministic Finite Automaton (DFA).

[5 marks]

(b) Define formally the language L accepted by a DFA M .

[3 marks]

(c) State the conditions and criteria for equivalence between two DFAs M1 and M2. [3 Marks]

(d) Let $M = (Q, \Sigma, \delta, S, F)$ be a finite automaton where $Q = \{q_0, q_1, q_2\}$, $\Sigma = \{0, 1\}$, $F = \{q_2\}$, start state $S = q_0$ and the transition function δ as $\delta(q_0, 0) = \{q_0, q_1\}$, $\delta(q_0, 1) = \{q_0\}$, $\delta(q_1, 1) = \{q_2\}$, $\delta(q_2, 0) = \{q_2\}$, $\delta(q_2, 1) = \{q_2\}$ and $L(M)$ be the language defined by M .

- i. Draw a transition diagram for M . [3 Marks]
- ii. Does M a DFA? Justify your answer. [3 Marks]
- iii. Give an example of a string in $L(M)$ and a string not in $L(M)$. [4 Marks]
- iv. Express $L(M)$ formally? [4 Marks]

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Question 2

All parts of this question are based on the automaton $M = (Q, \Sigma, \delta, S, F)$ where $Q = \{q_0, q_1, q_2\}$, $\Sigma = \{0, 1\}$, $F = \{q_2\}$, start state $S = q_0$ and the transition function δ defined as $\delta(q_0, 0) = \{q_0, q_1\}$, $\delta(q_0, 1) = \{q_0\}$, $\delta(q_1, 1) = \{q_2\}$, $\delta(q_2, 0) = \{q_2\}$.

- (a) Convert M into an equivalent deterministic finite automaton (DFA). [10 marks]

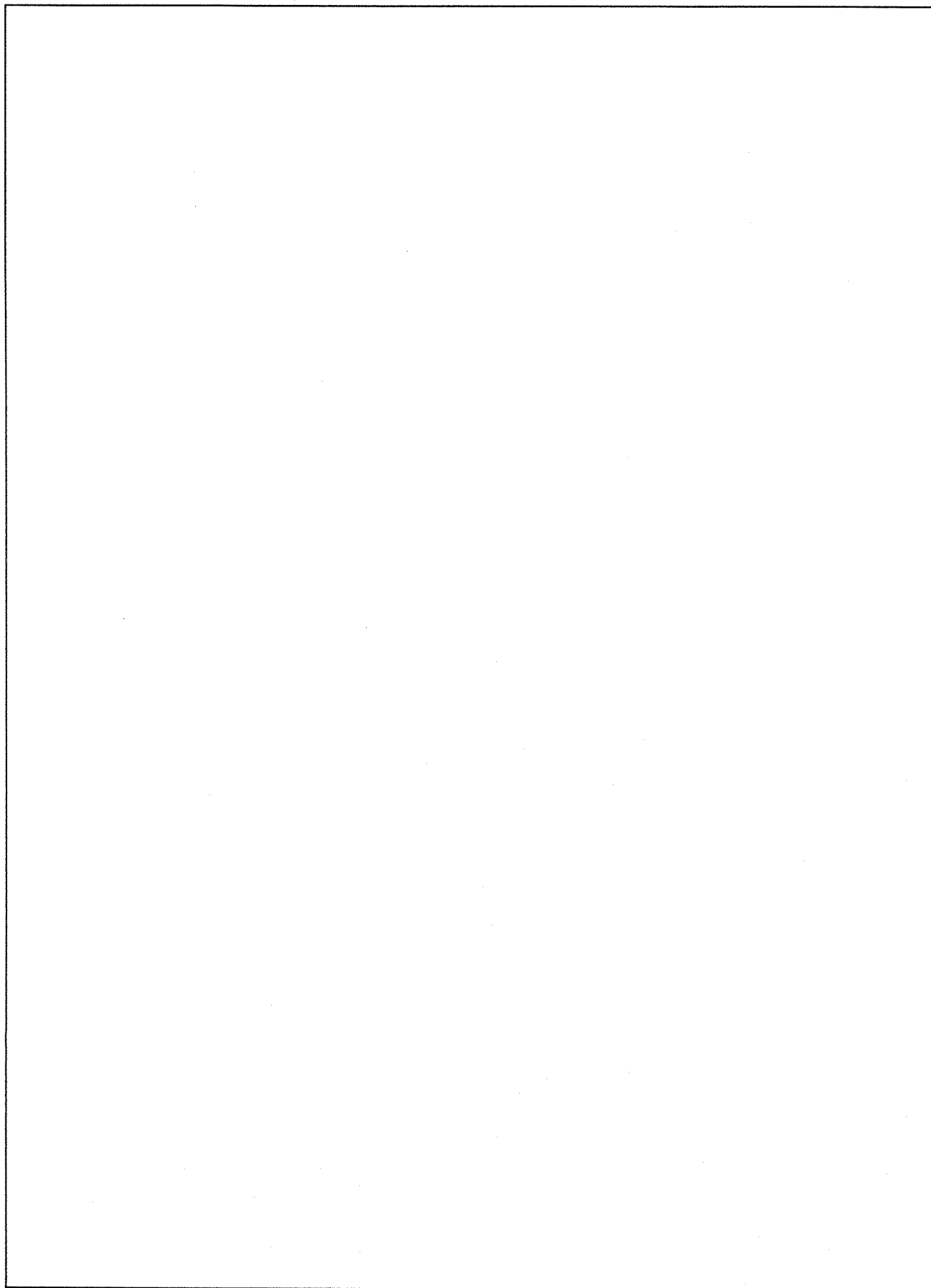
- (b) Derive a regular expression r for the automaton M .

[5 marks]

- (c) State the Arden's theorem for obtaining a regular expression for a given automaton. By applying the Arden's theorem obtain a regular expression for the automaton M .

[10 marks]

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Question 3

- (a) Statement: “*There can be a Regular Language which is not Context Free.*”

State whether the above statement is TRUE or FALSE, and justify your answer.

[4 Marks]

- (b) Consider the following two Context-Free Languages.

$$L1 = \{a^n b^n \text{ where } n > 0\}, \Sigma = \{a, b\}$$

$$L2 = \{c^m d^m \text{ where } m \geq 0\}, \Sigma = \{c, d\}$$

Show that $L1 \cup L2$ (Union) and $L1 . L2$ (Concatenation) are context-free. [4 Marks]

- (c) Let $\Sigma = \{ (,) , [,] \}$, $L = \{\text{properly nested strings from } \Sigma^* / \text{balanced parenthesis}\}$. For example: $[] \dots [[][]]$, $() \dots ((()))$, $([])$, $[()]$, $() []$, $[] ()$ are in L , but strings such as $[()]$, $([])$ are not.

Construct a Context Free Grammar to accept the above language

[6 marks]

- (d) Consider the following grammar where $\Sigma = \{1, 0\}$, $N = \{S, A, B, C\}$.

$$S \rightarrow 1A \mid 0BB$$

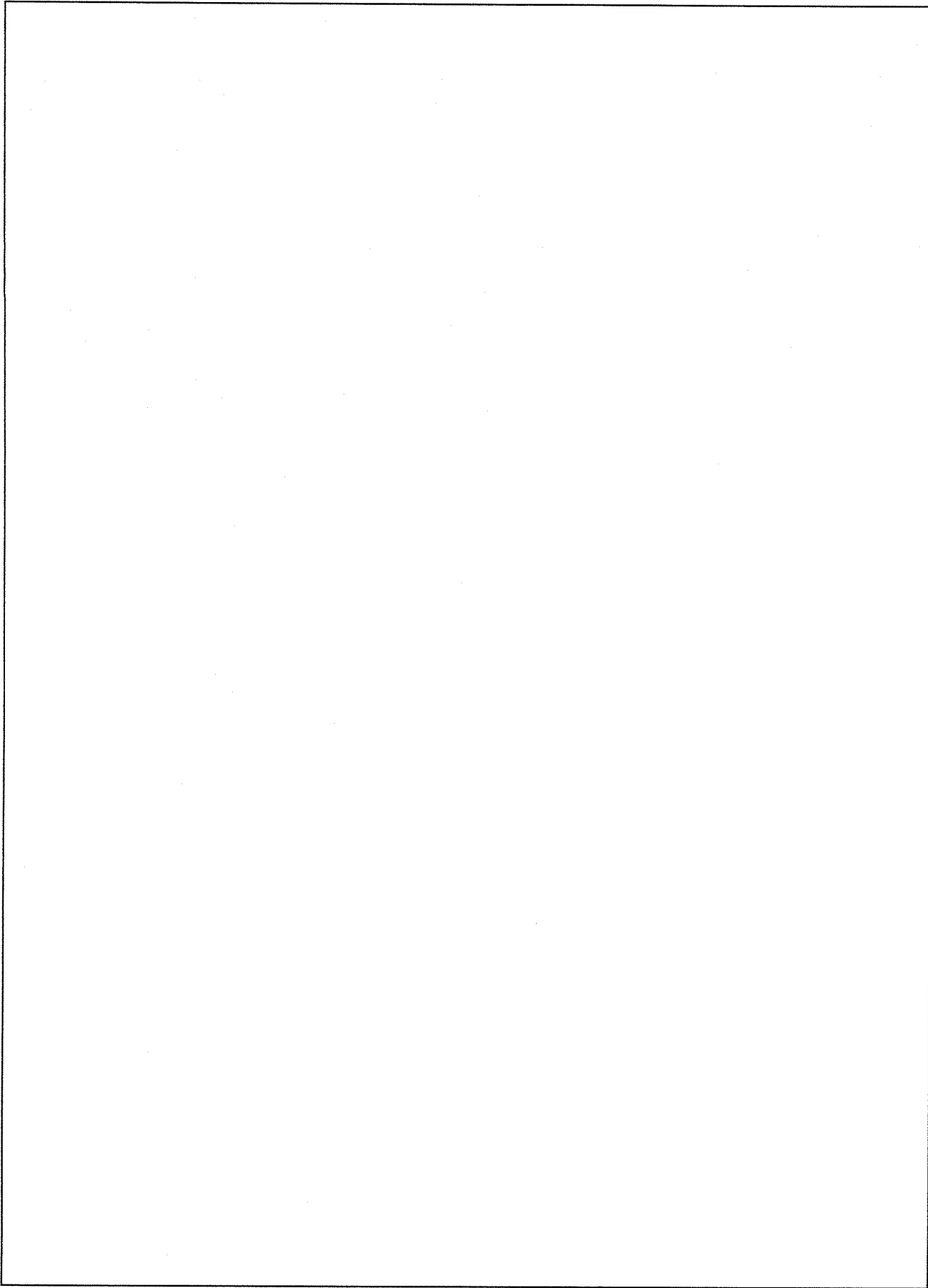
$$A \rightarrow 01A \mid \lambda$$

$$B \rightarrow 1B \mid 01C \mid \lambda$$

$$C \rightarrow B$$

- (i) Remove all useless productions, λ – productions and unit productions from the above grammar. [7 marks]
- (ii) Convert the resultant grammar into Greibach normal form. [4 marks]

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Question 4

(a). Give the formal definition of Non-Deterministic Pushdown Automata (NPDA).

[3 Marks]

(b) What is/are the advantage/s of adding the \$ symbol to the empty stack before reading the input characters in a PDA?

[3 Marks]

(c) While the language $L_1 = \{wcw^R : w \in \{a,b\}^*\}$ is deterministic, the closely related language $L_2 = \{ww^R : w \in \{a,b\}^*\}$ is known to be non-deterministic. Why? Justify your answer by giving suitable examples.

[4 Marks]

Parts (d) and (e) of the question are based on the push-down automata M defined as follows.

States = $\{q_0, q_1, q_2\}$
 Input Alphabet = $\{a, b\}$
 Stack Alphabet = $\{Z, A\}$
 Initial State = $\{q_0\}$
 Stack Start Symbol = $\{Z\}$
 Final State = $\{q_2\}$

Transition function δ defined as follows:

$\delta(q_0, a, Z) = \{(q_0, AZ)\}$, $\delta(q_0, a, A) = \{(q_0, AA)\}$,
 $\delta(q_0, b, A) = \{(q_1, A)\}$, $\delta(q_1, a, A) = \{(q_1, \lambda)\}$,
 $\delta(q_1, \lambda, Z) = \{(q_2, Z)\}$

(d) Draw a transition diagram for the automata.

[4 Marks]

(e) Show that the above push-down automata accepts the string **aaabaaa**. Justify your answer.

[3 Marks]

- (f) Construct a deterministic pushdown automata (DPDA) that accepts the following language on $\Sigma = \{a, b, c, d\}$. (*Hint: First define the PDA, including transition functions and then draw the state transition diagram*)

$$L = \{a^n b^m c^m d^n : n \geq 1, m \geq 1\}.$$

[8 Marks]
