-- 152

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: | | | | | | | | |

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]

Index No: .....

Index No: .....

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]

Index No: .....

Index No: .....

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.

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

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

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

(c) Let Σ = {(,) , [,]} , L = {properly nested strings from Σ^* /balanced parenthesis}. For example: [ ] ... [[[]]], ( ) ... ((())), ([]), [()], ( ) [ ], [ ] ( ) 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 Σ = {1, 0}, N = {S, A, B, C}.

S → 1A | 0BB
A → 01A | λ
B → 1B | 01C | λ
C → 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]

Index No: .....

Index No: .....

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 = {q0}
Stack Start Symbol = {Z}
Final State = {q2}

Transition function δ defined as follows:

$\delta(q_0, a, Z) = \{(q_0, AZ)\}$, $\delta(q_0, a, A) = \{(q_0, AA)\}$,
$\delta(q_0, b, A) = \{(q_1, A)\}$, $\delta(q1, a, A) = \{(q1, \lambda)\}$,
$\delta(q1, \lambda, Z) = \{(q2, Z)\}$

(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]

*****