33

University of Swaziland
Department Of Computer Science
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Title of paper: *Theory of Computation*

Course number: *CS211*

Time Allowed: *Three (3) hours*

Instructions:

- *This paper consists of* ***six (6)*** *questions.*
- *Each question is worth* ***25*** *marks*
- *Answer* ***any four (4)*** *questions from questions 1 to 6.*

This paper may not be opened until permission has been granted by the invigilator

QUESTION 1

(a) What is a formal language [2]

(b) Let r be an expression. When is r said to be a regular expression over an alphabet $\sum$. [2]

(c) With the aid of an example, explain the difference between a deterministic finite acceptor (DFA) and a non-deterministic finite acceptor(NFA) [3]

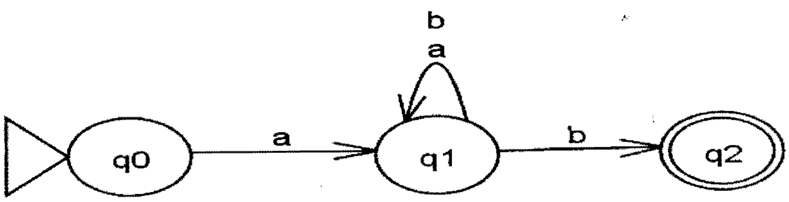
(d) Construct a NFA for each of the following regular expressions over the alphabet $\sum = \{a, b, c\}$

(i) $r = \Phi$ [2]

(ii) r = ab + c* [3]

(iii)r = bc*a [3]

(e) Consider the following finite automaton.



(i) Write the regular expression for the language accepted by the automaton. [4]

(ii) Write the regular grammar for the language accepted by the automaton. [4]

(iii)Describe the language accepted by the finite automaton. [2]

QUESTION 2

(a) Write the design of a Turing Machine (TM) to compute $F(x) = 3x + 1$. Assume x to be a non zero positive integer in unary representation. Clearly write the functional steps of your TM computations. Also write the instantaneous descriptions using the value of x as 1111 and 111111 (in unary representation) for your Turing Machine. [15]

(b) With the aid of an example, explain what is meant ambiguity in grammars and languages. [5]

(c) With the aid of examples, explain the nature and main cause of the dangling-else problem in some computer programming languages such as C, C++ and Java. Explain two possible solutions to this problem. [5]

QUESTION 3

(a) Consider the following Grammar G = ({S}, {0,1}, S, P) where the production rules P are $S \rightarrow 11S0 \mid 0$

(i) List four different strings generated by the grammar G. [2]

(ii) Describe the language generated by the grammar G [2]

(iii)Is G a linear grammar? Explain your answer. [2]

(iv) Draw a transition graph for the finite automaton that accepts the language generated by the grammar G. [3]

(v) Is G a right linear grammar? If not, write an equivalent right linear grammar for G. Show all your working. [3]

(b) Consider the following grammar:

$S \rightarrow aABB \mid aAA$

$A \rightarrow aBB \mid a$

$B \rightarrow bBB \mid A$

(i) Construct a nondeterministic pushdown automaton (npda) that accepts the language generated by the grammar G. [5]

(ii) List four strings of length 7 or more that are accepted by G. [4]

(iii) Show the sequence of moves taken by the npda in accepting the two of the string: **aaaaa** and **aabaaa** [4]

QUESTION 4

(a) Using extended BNF notation, write grammar production rules, and the corresponding syntax diagrams, for the following C/C++ constructs. YOU DO NOT NEED TO WRITE THE RULES FOR ALL OTHER POSSIBLE STATEMENT.

(i) if –else statement [5]

(ii) while statement [5]

(b) Design a deterministic pushdown automaton (DPDA) to recognize the language

$$L = \{\ w\ \in a^n b^{3n}, n \geq 0\}$$

Give functional steps and clearly describe as to how your DPDA accepts strings in L and rejects strings not in L. Write instantaneous descriptions for $w_1 = aabbbbbb$ and $w_2 = abbb$ [15]

QUESTION 5

(a) Consider the finite automatom $M = (\{q_0, q_1\}, \{a,b,c\}, \delta, q_0, \{q_1\})$ where δ is defined by the following transition table:

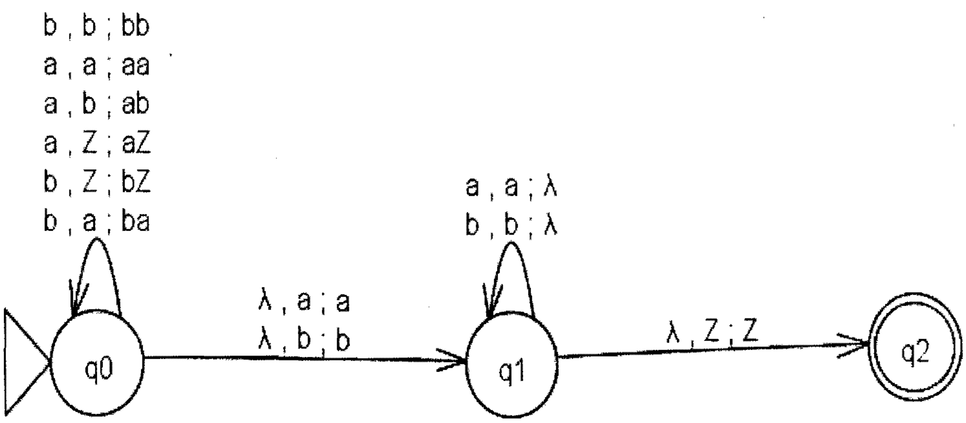
δ	a	b	c
q_0	$\{q_0, q_1\}$	$\{q_1\}$	
q_1		$\{q_0, q_1\}$	$\{q_1\}$

(i) What are the key features of a deterministic finite automaton? Explain why M is not a deterministic finite automaton. [5]

(ii) Construct a transition graph for the finite automata M. [3]

(iii) Convert the NFA obtained in (i) above to a deterministic finite automaton? [5]

(b) Consider the following Non-Deterministic Pushdown automata M



(i) Show the sequence of moves in accepting the string ***aabbaa*** **.** Show all your steps. [4]

(ii) List 3 more strings that are accepted by M. [3]

(iii) Write a textual description of the language L(M) accepted by M. [2]

(iv) Write a grammar for the language accepted by M. [3]

QUESTION 6

(a) Write the design of a Turing Machine (TM) that accepts L ={$a^n b^n$: n >= 1}. Write the instantaneous description when the input is aaabbb [10]

(b) Consider the grammar G = ({S, A, B, C,}, {a,b}, S, P) where the production rules are:

$$S \rightarrow abAB$$

$$A \rightarrow bAB \mid \lambda$$

$$B \rightarrow BAa \mid A \mid \lambda$$

(i) Eliminate all unit productions, all useless productions, and λ-productions from the grammar G. Show all your workings. [5]

(ii) Transform the grammar G, given above, into Chomsky Normal Form (CNF)? [5]

(iii) Transform the grammar G, given above,, into Greibach Normal Form (GNF). [5]