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University of Swaziland
Department Of Computer Science
DECEMBER 2015

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 [1]

(b) With the aid of an example, explain the difference between a non-deterministic pushdown automata (NPDA) and a non-deterministic finite acceptor(NFA) [2]

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

(i) $r = \emptyset$+ a [2]

(ii) $r = a^*b + bc$ [3]

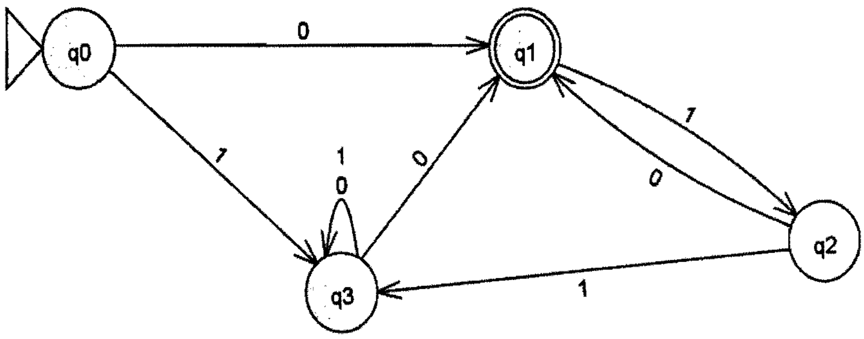
(d) Consider the grammar G = ({S}, {a,b}, S, P) where the production rules are: S → aS, S → bS, S → λ.

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

(ii) List four different strings of length 4 or more that can be generated by the grammar G. [2]

(iii) Construct a finite automaton that accepts the language generated by the grammar G. [3]

(e) Consider the 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) Describe the language generated by the grammar G = ({S}, {0,1}, S, P) where the production rules P are $S \rightarrow 0S1 \mid 11$ [2]

(b) Construct a transition graph for the finite automaton that accepts the language generated by the following grammar: G = ({S, A, B}, {a,b}, S, P) where the production rules are $S \rightarrow bbA$, $S \rightarrow abB$, $A \rightarrow abaS$, $B \rightarrow babS$, $S \rightarrow \lambda$ [4]

(c) ...

(i) Construct a transition graph for the finite automata M = ($\{q_0, q_1\}$, {a,b,c}, δ, q_0, $\{q_1\}$) where δ is defined by the following transition table:

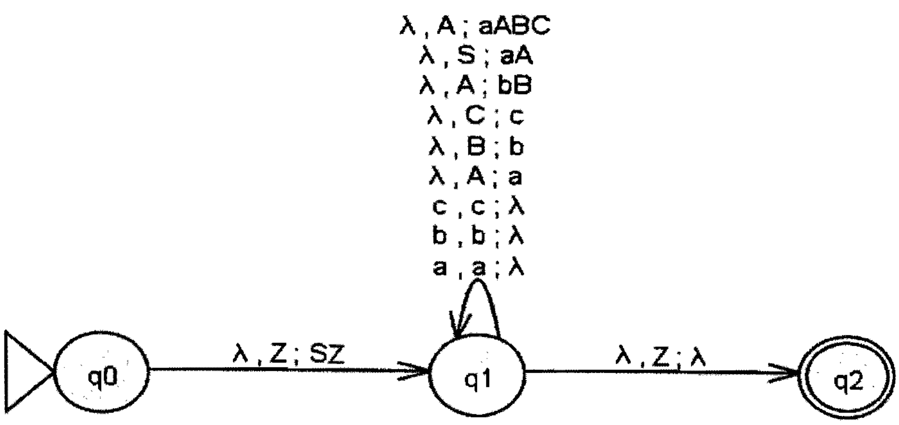
[2]

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

(ii) Convert the NFA obtained in (i) above to a deterministic finite automaton?

[5]

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



(i) Show the sequence of moves in accepting the string ***aaabc*** [5]

(ii) List 3 more strings that are accepted by M. [2]

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

QUESTION 3

(d) Write the design of a Turing Machine (TM) to compute $f(x) = x + y$.

Assume x and y to be a non zero positive integer in unary representation. [5]

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

$$S \rightarrow aA \mid aBB$$
$$A \rightarrow aaA \mid \lambda$$
$$B \rightarrow bB \mid bbC$$
$$C \rightarrow B$$

(i) Eliminate all unit productions, all useless productions, and λ-productions from the grammar G. Show all your workings. [10]

(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]

QUESTION 4

(a) Construct a Non-Deterministic Pushdown automaton (npda) that accept the following languages on L_1 = L(baa*b) [5]

(b) Construct a Non-Deterministic Pushdown automata (npda) that accept the language generated by each of the following grammar: S → aSaA | A, A → aAb | b

[5]

(c) Write the design of a Turing Machine (TM) to compute $F(x) = 2x + 1$
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]

QUESTION 5

(a) With the aid of an example, explain what is meant ambiguity in grammars and languages. [3]

(b) The Swaziland Government uses two formats for Vehicle Registration Numbers. The general format for public or privately owned vehicles starts with 3 letters, followed by 3 digits and 2 letters. Examples are: ASD380OS, BSD278BM, XSD272AM. Government owned cars have a similar format but the first letter is always the letter G, and the last two letters indicate the ministry/dapartment that owns the vehicle. Examples are: GSD101HE, GSD008TI, GSD272WO where HE, TI and WO are special codes fron the Ministry of Health, Tinkhunda and Works and Transport.

Using Backus Naur Form (BNF) notation, write a Context free Grammar that could be used to generate the Swaziland Vehicle Registration numbers.

[6]

(c) 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 [3]

(ii) while statement [4]

(iii)for statement [4]

(d) 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 6

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

$$L = \{ \ w \ \in a^{2n}b^n, n \geq 0\}$$

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 $w_1 = aaaabb$ and $w_2 = aab$ [13]

(b) Design a non deterministic pushdown automaton (NDPA) to recognize the language generated by the grammar G ({S,Z,B}, {a,b}, S, P) where the set of productions P is:

$S \rightarrow aBZ \mid aZ \mid aB \mid a$

$B \rightarrow bB \mid b$

$Z \rightarrow aBZ \mid aZ \mid BZ \mid a$

Write instantaneous descriptions for w = aaab. [12]