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## KIRIRI WOMENS' UNIVERSITY OF SCIENCE AND TECHNOLOGY UNIVERSITY EXAMINATIONS, 2024/2025 ACADEMIC YEAR THIRD YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (COMPUTER SCIENCE)

### KCS 2308: FORMAL LANGUAGES AND AUTOMATA THEORY

#### **DATE: 13<sup>TH</sup> DECEMBER, 2024 TIME: 11:30AM-1:30PM**

#### <u>INSTRUCTIONS TO CANDIDATES</u> <u>ANSWER QUESTION ONE (COMPULSORY)</u> AND ANY OTHER TWO QUESTIONS

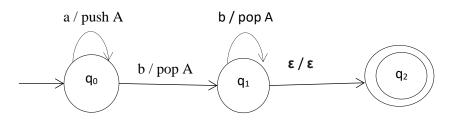
# **QUESTION ONE: COMPULSORY (30 MARKS)**

a)	Given the alphabets $\Sigma_1 = \{0, 1\}$ and $\Sigma_2 = \{a, b, c\}$ Identify the concatenation $\Sigma_1 \Sigma_2$	(2 Marks)
b)	Distinguish between	
	i) terminal and non-terminal symbols	(2 Marks)
	ii) $X = \{a, b, c, d\}$ and $Y = \{1, 2, 3, 4,\}$	(2 Marks)
	iii) inductive and deductive proof	(2 Marks)
	iv) right linear grammar and left linear grammar	(2 Marks)
	v) 5 <sup>*</sup> and 5 <sup>+</sup>	(2 Marks)
c)	Determine  S  if S='cabcad'	(2 Marks)
d)	Describe (in English) the language defined by the following regular expression:	
,	(letter   _ ) (letter   digit   _ )*	(2 Marks)
e)	Given the language $L = \{aaa, aab, aba, abb, baa, bab, bba, bbb\}$ determine its regular express	ion L(r)
		(2 Marks)
f)	If $\Sigma = \{0, 1\}$ , what is $\Sigma^n$ when n=4	(2 Marks)
g)	With the aid of a diagram highlight the various types of grammars described in the Chomsky	hierarchy
		(2 Marks)
h)	State how the output in a Mealy machine is affected by changes in input, as compared to a M	oore machine
		(2 Marks)
i)	With reference to the Church-Turing thesis highlight whether artificial intelligence systems c	an ever
	surpass human reasoning	(2 Marks)
j)	Explain how ambiguity affects the parsing of a language	(2 Marks)
k)	With reference to the Halting Problem highlight whether artificial intelligence systems can be	e designed to
	solve every computational problem	(2 Marks)

## **QUESTION TWO (20 MARKS)**

a)	Provide the formal representation of a push-down automata (PDA)	(4 Marks)
b)	Explain the role of stacks within PDA	(3 Marks)
c)	Highlight how PDAs are more powerful than FAs when it comes to language recognition	(2 Marks)
d)	Given a context-free language L= $\{a^n b^n   n \ge 1\}$ provide a step by step description of how a I	PDA works to

recognize the string "aabb" (6 Marks)

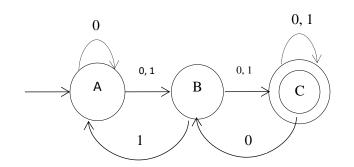


e) Design a basic PDA for recognizing palindromes over the alphabet  $\sum = \{a, b\}$  (5 Marks)

### **QUESTION THREE (20 MARKS)**

- a) Design a finite automata (FA) for the following regular expression: xy+(x+yy)y (5 Marks)
- b) Draw a deterministic finite automaton (DFA) that recognizes the language over the Alphabet  $\Sigma = \{0, 1\}$  consisting of all those strings that contain an odd number of 1's (3 Marks)
- c) Provide the meaning of the following:  $\delta(q_3, a) = \{q_0, q_1, ..., q_n\}$
- d) Given the below NDFA. Provide its equivalent DFA using the subset construction method [show all steps used]
  (6 Marks)

(2 Marks)



e) Highlight the basic limitation of a finite automata (2 Marks) f) Differentiate between regular and non-regular languages with reference to finite automata (2 Marks) **QUESTION FOUR (20 MARKS)** a) Provide the formal representation of a context free grammar (CFG) (4 Marks) b) Given the language L=  $\{a^n b^m | n \ge 0, n \le m \le 2n\}$  Generate the CFG for L (4 Marks) c) Given a string of the form  $a+a^*a$ . Let the set of production rules in a CFG over an alphabet  $\Sigma = \{a\}$  be  $X \rightarrow X + X \mid X * X \mid X \mid a$ Provide the leftmost derivation for the string (3 Marks) i. Provide the rightmost derivation for the string (3 Marks) ii. Provide a unique set of productions for the string iii. (3 Marks) Provide the parse tree for the string using the unique set of productions obtained in (iii) above iv. (3 Marks) **QUESTION FIVE (20 MARKS)** a) Provide the formal representation of a Turing Machine (6 Marks) b) Design a Turing Machine for an equal number of a's and b's (4 Marks) Identify **TWO** extensions of Turing machines c) (2 Marks) d) Distinguish between unsolvable and undecidable problems with reference to Turing Machines (2 Marks) e) Provide the meaning of the following:  $\delta$  (q<sub>3</sub>, 1, R) (2 Marks)

f) Outline FOUR basic features of Turing Machines that differentiate them from finite automata(4 Marks)