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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: 13TH DECEMBER, 2024
TIME: 11:30AM-1:30PM

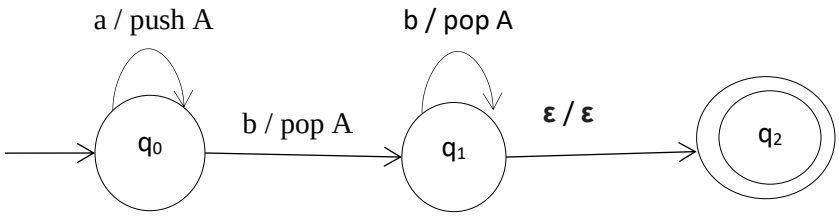
INSTRUCTIONS TO CANDIDATES
ANSWER QUESTION ONE (COMPULSORY) AND ANY OTHER TWO QUESTIONS

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^* and 5^+ **(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 expression L(r) **(2 Marks)**
f) If $\Sigma = \{0, 1\}$, what is Σ^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 Moore machine **(2 Marks)**
i) With reference to the Church-Turing thesis highlight whether artificial intelligence systems can 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 designed to solve every computational problem **(2 Marks)**

QUESTION TWO (20 MARKS)

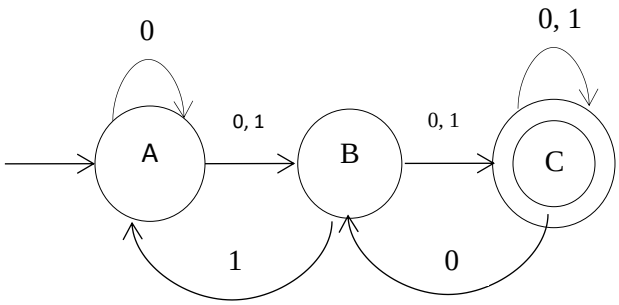
a) Provide the formal representation of a push-down automata (PDA) **(4 Marks)**
b) Explain the role of stacks within PDA **(3 Marks)**
c) Highlight how PDAs are more powerful than FAs when it comes to language recognition **(2 Marks)**
d) Given a context-free language $L= \{a^n b^n | n \geq 1\}$ provide a step by step description of how a 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 $\sum = \{0, 1\}$ consisting of all those strings that contain an odd number of 1's **(3 Marks)**
c) Provide the meaning of the following: $\delta (q_3, a) = \{q_0 , q_1 , \ldots, q_n\}$ **(2 Marks)**
d) Given the below NDFA. Provide its equivalent DFA using the subset construction method [show all steps used] **(6 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 $L= \{a^n b^m | \ n \geq 0, n \leq m \leq 2n\}$ 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 $\sum = \{a\}$ be

$$X \rightarrow X+X \mid X*X \mid X \mid a$$

i. Provide the leftmost derivation for the string **(3 Marks)**
ii. Provide the rightmost derivation for the string **(3 Marks)**
iii. Provide a unique set of productions for the string **(3 Marks)**
iv. Provide the parse tree for the string using the unique set of productions obtained in (iii) above **(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)**
c) Identify **TWO** extensions of Turing machines **(2 Marks)**
d) Distinguish between unsolvable and undecidable problems with reference to Turing Machines **(2 Marks)**
e) Provide the meaning of the following: $\delta (q_3, 1, R)$ **(2 Marks)**
f) Outline **FOUR** basic features of Turing Machines that differentiate them from finite automata **(4 Marks)**