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**KIRIRI WOMENS' UNIVERSITY OF SCIENCE AND TECHNOLOGY
UNIVERSITY EXAMINATION, 2016/2017 ACADEMIC YEAR
THIRD YEAR, SECOND SEMESTER EXAMINATION
FOR THE DEGREE OF BACHELOR OF SCIENCE
(COMPUTER SCIENCE)**

Date: 8th August, 2016.
Time: 11.00am – 1.00pm

KCS 308 - FORMAL LANGUAGES AND AUTOMATA THEORY

INSTRUCTIONS TO CANDIDATES

ANSWER QUESTION ONE (COMPULSORY) AND ANY OTHER TWO QUESTIONS

QUESTION ONE (30 MARKS)

- a) Given the language $L(b(a^*Ub^*)a)$;
- i) Generate two strings of length six. (4 Marks)
 - ii) Explain any two restriction placed on this language. (2 Marks)
 - iii) What is the shortest string that can be gotten from this language? (2 Marks)
- b) Assuming a computer takes 2s to load the JVM and can then execute one Java println instruction every 20ns;
- i) Try to provide a formula to indicate how long each program would take to terminate as a function of N. Assume that all instructions other than println take 0 ns to execute. (3 Marks)
 - ii) How many lines will be printed according to the value of N? (1, 5, 10 and 50)

```
public class ExampleProgram{
    static int line = 1;
    public static void main(String args[]) {
        int N = Integer.parseInt(args[0]);
        for(int i=0;i<N;i++)
            for(int j=0;j<2;j++)
                System.out.println("Line " + line++);
    }
}
```

(2 Marks)

b) Let G be the grammar;

$$\begin{aligned} S & \rightarrow aS \mid aAb \\ A & \rightarrow aA \mid b \end{aligned}$$

i) Produce two left-most derivations for the string "aaabb and build the parse trees for the derivations. (6 Marks)

ii) Is this grammar ambiguous? Why or why not? (2 Marks)

iii) Give a regular expression for the language of this grammar (2 Marks)

c) Let M be the DFA $(Q, \Sigma, \delta, q_0, F)$ where;

$Q = \{q_0, q_1\}, \Sigma = \{0, 1\}, F = \{q_0\}$ and δ is

δ	0	1
q_0	q_0	q_1
q_1	q_1	q_0

L(M) is strings over $\{0, 1\}$ which contain an even number of 1's. Draw the DFA for the above language.

(7 Marks)

QUESTION TWO (20 MARKS)

a) Give a regular expression and an equivalent NFA for the language over $\{a,b,c\}$ that starts with aa and contains the substring ba. (8 Marks)

b) Giving relevant examples, define the following words as used in automata theory;

i) Alphabet

ii) String

iii) Language

iv) Regular expression

(8 Marks)

c) Use set notation to define the language of the grammar below;

$$S \rightarrow aS \mid aA \mid c$$

$$A \rightarrow Ab \mid \lambda$$

(4 Marks)

QUESTION THREE (20 MARKS)

a) Given the following grammar, generate the string abac;

i. ii. $S \rightarrow aB \mid bS \mid cS \mid \lambda$

iii. iv. $B \rightarrow aB \mid bC \mid cS \mid \lambda$

v. vi. $C \rightarrow aB \mid bS \mid \lambda$

(4 Marks)

- b) A deterministic finite automaton is a quintuple $M = (Q, \Sigma, \delta, q_0, F)$. Explain the meaning of each of the symbols in the bracket. (8 Marks)
- c) A context-free grammar G is a quadruple (V, Σ, R, S) . Explain the meaning of each of the symbols in the bracket. (8 Marks)

QUESTION FOUR (20 MARKS)

- a) Construct a grammar over $\{a,b\}$ which recognises the language $\{a^i b^{2i} \mid i \geq 1\}$ (5 Marks)
- b) Consider a machine M which accepts strings over $\{0, 1\}$ which do not contain three consecutive 1's, i.e.
 $Q = \{q_0, q_1, q_2, q_3\}$, $\Sigma = \{0, 1\}$,
 $F = \{q_0, q_1, q_2\}$ and δ is
- Draw the DFA of the above language. (9 Marks)

- c) Let G be the grammar;
- $S \rightarrow aS \mid aA \mid a$
 $A \rightarrow aAb \mid ab$
- i) Using this grammar, produce a rightmost and a leftmost derivation of the string "aaaabb". (Add top-down and bottom-up parsing as well) (4 Marks)
- ii) Build the parse trees for the derivations from part. (2 Marks)

QUESTION FIVE (20 MARKS)

- a) Give a regular expression that represents each of the following sets and build an equivalent NFA;
- i) The set of strings over $\{a,b,c\}$ in which all the a's precede the b's, which in turn precede the c's. (6 Marks)
- ii) The set of strings over $\{a,b,c\}$ that begin with a, contain exactly two b's and end with cc. (6 Marks)
- b) For the following languages below, either give a context-free grammar or indicate why this is not possible;
- i) $\{a^i b^j c^k \mid i \neq j, i, j, k \geq 0\}$ (2 Marks)
- ii) $\{a^i b^j c^k \mid j \neq k, i, j, k \geq 0\}$ (2 Marks)
- iii) $\{a^i b^j c^k \mid i \neq j \text{ or } j \neq k, i, j, k \geq 0\}$ (2 Marks)
- iv) $\{a^i b^j c^k \mid i \neq j \text{ and } j \neq k, i, j, k \geq 0\}$ (2 Marks)