MANICALAND STATE UNIVERSITY OF APPLIED SCIENCES

FACULTY OF ENGINEERING, APPLIED SCIENCES AND TECHNOLOGY

DEPARTMENT: COMPUTER SCIENCE AND INFORMATION SYSTEMS

MODULE: THEORY OF COMPUTATION

CODE: BCOS212

SESSIONAL EXAMINATIONS
DECEMBER 2023

DURATION: 3 HOURS

EXAMINER: MS C KATSANDE

INSTRUCTIONS

1. *Answer **Any 4** questions*
2. *Each question carries 25 marks*
3. *Start a new question on a fresh page*
4. *Total marks 100*

Additional material(s): *None*

Question 1

a) Enumerate four (4) real-world applications that can be developed using Finite State Machines (FSMs). For each application, describe how FSMs are utilized to model and control the system's behaviour. **12 Marks**

b) Prove that for every integer n, if n is odd, then n^2 is odd. **4 Marks**

c) Consider the following transition table:

States	Next State for Input a	Next State for Input b
q_0	q_1	q_2
q_1	q_1	q_3
q_2	q_2	q_3
$*q_3$	q_3	q_3

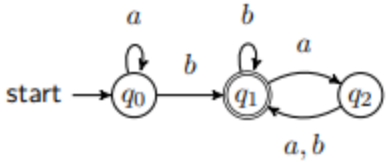
i. Draw the transition graph for this automaton**.** **5 Marks**

ii. Give its formal definition (no need to rewrite the function δ). **4 Marks**

Question 2

a) Construct a Deterministic Finite Automata (DFA) for the language accepting strings ending with '0011' over input alphabets $\sum = \{0, 1\}$. **8 Marks**

b) Given the following Deterministic Finite Automata (DFA)



Check if it accepts or reject the following strings:

i) bbab **4 Marks**

ii) aaba **4 Marks**

c) Outline any four (4) applications of regular expressions. **4 Marks**

d) Explain the language described by the regular expression $(0 \cup 1)\,((0 \cup 1)(0 \cup 1))^*$ and provide examples of strings that would be accepted by it. **5 Marks**

Question 3

a) Construct a Non-deterministic Finite Automata (NFA) in which all the string contains a substring 1101. **8 Marks**

b) Given the Context-Free Grammar $G_{2=}$

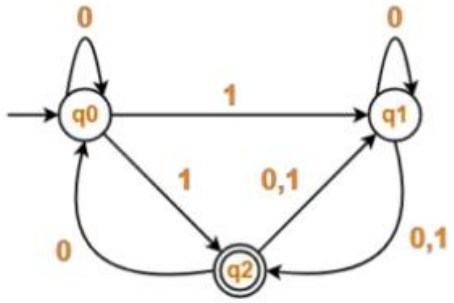
⟨SENTENCE⟩ → ⟨NOUN-PHRASE⟩⟨VERB-PHRASE⟩
⟨NOUN-PHRASE⟩ → ⟨CMPLX-NOUN⟩ | ⟨CMPLX-NOUN⟩⟨PREP-PHRASE⟩
⟨VERB-PHRASE⟩ → ⟨CMPLX-VERB⟩ | ⟨CMPLX-VERB⟩⟨PREP-PHRASE⟩
⟨PREP-PHRASE⟩ → ⟨PREP⟩⟨CMPLX-NOUN⟩
⟨CMPLX-NOUN⟩ → ⟨ARTICLE⟩⟨NOUN⟩
⟨CMPLX-VERB⟩ → ⟨VERB⟩ | ⟨VERB⟩⟨NOUN-PHRASE⟩
⟨ARTICLE⟩ → `a` | `the`
⟨NOUN⟩ → `boy` | `girl` | `flower`
⟨VERB⟩ → `touches` | `likes` | `sees`
⟨PREP⟩ → `with`

Show that the string *the girl touches the boy with the flower* has two different leftmost derivations in grammar G_2. **10 Marks**

c) Create a context free grammar of non-regular language L1 = { $a^n b^n$ | n is a positive integer }. **7 Marks**

Question 4

a) Convert the following Non-Deterministic Finite Automata (NFA) to its equivalent Deterministic Finite Automata (DFA). **9 Marks**



b) Check whether the following grammar is ambiguous or not for string *w = aabbccdd*

6 Marks

S → AB / C
A → aAb / ab
B → cBd / cd
C → aCd / aDd
D → bDc / bc

c) Convert the given Context Free Grammar (CFG) into an equivalent Chomsky Normal Form (CNF). **10 Marks**

$S \rightarrow ASA|aB$

$A \rightarrow B|S$

$B \rightarrow b|\epsilon$

Question 5

a) Given a language $L = 0^N1^N$ where $N>0$

i) Give an implementation-level algorithm of a Turing machine that decides the language. **5 Marks**

ii)Design a Turing Machine which recognizes the given language. **10 Marks**

b) List any five (5) differences between the complexity classes P and NP. Provide an example of a problem that belongs to each class and justify why it belongs to the class.

10 Marks

END OF EXAMINATION