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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
Department of Computer Science and Engineering (CSE)

MID SEMESTER EXAMINATION
 DURATION: 1 HOUR 30 MINUTES

WINTER SEMESTER, 2022-2023
 FULL MARKS: 75

CSE 4703: Theory of Computing

Programmable calculators are not allowed. Do not write anything on the question paper.
 Answer all 3 (three) questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

1. a) Explain if each of the following assertion is correct or incorrect. 4 × 2.25
- i. Epsilon transitions make NFAs more powerful than DFAs, in terms of the languages they can express. (CO2) (PO1)
 - ii. Given an NFA with N states, the corresponding DFA always have 2^N states (assuming we explicitly include dead states).
 - iii. For every pair of regular expressions R and S , the languages denoted by $R(SR)^*$ and $(RS)^*R$ are the same.
 - iv. Every context free language (CFL) is the class of regular language.
- b) Design a deterministic finite automaton (DFA) for the language, $L = \{w|w \text{ has an equal number of '01's and '10's over the } \Sigma = \{0, 1\}^*\}$ 8 (CO2) (PO1)
- c) Consider the following NFA over the alphabet $\{a\}^*$ illustrated in Figure 1. Convert this NFA to an equivalent DFA. 8 (CO1) (PO1)

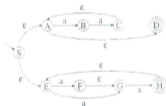


Figure 1: NFA for Question 1.c)

2. a) Let L be a language defined as, 3 × 3
- $$L = \{ abXa\{a, b\}^* \mid X = a^n \text{ where } n \text{ is even, or } X = b^n \text{ where } n \text{ is odd.} \}$$
- (CO2) (PO1)
- Answer the following questions about L :
- i. Draw the DFA or NFA for the language L .
 - ii. Determine the regular expression for the language L .
 - iii. Is L a regular language? Justify your answer.
- b) Design the DFA / NFA for the following regular expression R over $\Sigma = \{a, b\}^*$. 8
- $$R = bb^*(a + ab + ba)(ab)^*(a + b)^*$$
- (CO2) (PO1)

- c) The nondeterministic finite automaton (NFA), $N_1 = (Q_1, \Sigma, \delta_1, q_1, F_1)$ recognizes the language L_1 . Construct L_1^* that recognizes $N = (Q, \Sigma, \delta, q, F)$ Write down the expression for each of the tuple. If required, draw the necessary diagrams. 8
(CO1)
(PO1)

3. a) Robel was tasked with developing a Context Free Grammar (CFG) for basic mathematical expressions like addition, multiplication, and deduction. She came up with the following grammar. 3 × 3
(CO2)
(PO2)

$$E \rightarrow id \mid E + E \mid E * E \mid E - E$$

Based on Robel's grammar, answer the following question.

- i. What is ambiguous grammar? Is the above grammar ambiguous? 8
 - ii. Draw two parse trees for the string $id + id * id$. (CO1)
 - iii. Write an unambiguous grammar for the same language (PO1)
- b) Write down the three pumping lemma criteria that a language must meet in order to be considered a regular language. Apply pumping lemma for regular languages to prove that the following language is not regular. 8

$$L = \{a^m b^n a^m \mid m, n \geq 0 \text{ and } \Sigma = \{a, b\}^*\}$$

- c) Give context free grammar that generates the following language L . 8

$$L = \{a^i b^j c^k \mid i, j, k \geq 0 \text{ and } i + j = k\}$$
(CO2)
(PO1)