

# Formal Language and Automata Theory (CS21004)

## Tutorial - IV

Class: CSE 2<sup>nd</sup> Year

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**Exercise 1.** Consider the language  $L = \{x \in \{a, b\}^* : x = x^R\}$ , give three grammars for the language, one of them must have non-context-free production rule.

**Exercise 2.** Give context-free grammars for the following languages:

- i.  $L_1 = \{a^i b^j a^k : i, j, k > 0 \text{ and } j \geq i + k\}$ ,
- ii.  $L_2 = \{a^p b^q a^r b^s : p, q, r, s \geq 0, p > q \text{ and } r < s\}$ ,

**Exercise 3.** Let  $L_{31}$  and  $L_{32}$  be two CFLs over the alphabet  $\Sigma$ , specified by the CFGs  $G_{31}$  and  $G_{32}$ . Justify the following claims.

- a)  $L_{31} \cup L_{32}$  is a CFL,
- b)  $L_{31} L_{32}$  is a CFL,
- c)  $(L_{31})^*$  is a CFL,
- d) If  $h: \Sigma \rightarrow \Gamma^*$  be a mapping, then  $h(L_{31})$  is a CFL.

**Exercise 4.** Design DFA for the following languages over the alphabet  $\Sigma = \{0, 1, 2\}$ :

- a)  $L_{4a} = \{x \in \{0, 1, 2\}^* : x \text{ has odd number of substrings } 210\}$ ,
- b)  $L_{4b} = \{x \in \{0, 1, 2\}^* : x \text{ does not have any substring } 210\}$ ,
- c)  $L_{4c} = \{x \in \{0, 1, 2\}^* : x \text{ either has the substring } 01 \text{ or has the substring } 021\}$ .