

## Assignment 3 and 4 – CS 301 - Theory of Automata – Fall 2020

Due: Wednesday, November 11, 2020 (online – 11 PM)

Note: Late submissions will have 25% deduction. Submission after Friday (Nov 13 – 2 PM) will not be accepted.

### Assignment 3 [Total marks = 50]

#### 1. [8 \* 5]

Define CFGs for the following languages. For parts a-g, set of terminals is {a, b}. For part h, set of terminals is {a, b, c}

- $A = \{ w \in \{a, b\}^* \mid \text{All words in which the letter } b \text{ is never tripled} \}$   
<http://suraj.lums.edu.pk/~cs311w05/hw/HW05.pdf>
- $B = \{ w \in \{a, b\}^* \mid \text{All words that do not have the substring } abb \}$   
<http://suraj.lums.edu.pk/~cs311w05/hw/HW05.pdf>
- $C = \{ w \in \{a, b\}^* \mid \text{number of a's and number of b's are equal} \}$   
<https://math.stackexchange.com/questions/2207708/context-free-grammar-for-language-a-b-where-the-number-of-as-the-number>
- The language D of strings of properly balanced left and right brackets: every left bracket can be paired with a unique subsequent right bracket, and every right bracket can be paired with a unique preceding left bracket. Moreover, the string between any such pair has the same property.  
For example,  $[ ] [ [ [ ] ] ] [ ] ] \in D$ .  
<https://web.njit.edu/~marvin/cs341/hw/hw05.pdf>
- $E = \{ a^n b^m a^{2n} \mid n, m > 0 \}$
- $F = \{ a^n b^m a^k \mid k = m + 2n \}$
- $G = \{ a_i b_j \mid 3i \leq j \leq 4i \}$   
<https://courses.engr.illinois.edu/cs373/fa2010/> homework 9 sol
- $H = \{ w \in \{a, b, c\}^* \mid \text{number of a's and number of b's are equal or number of b's and number of c's are equal} \}$   
<https://courses.engr.illinois.edu/cs373/fa2010/Exams/sp10mockfinalsol.pdf>

#### 2. [10]

In this question, you shall be designing grammar for Roman Number System from 1 – 399.

For this question, your set of terminals is {i, v, x, l, c}.

In Roman number system, i stands for 1, v stands for 5, x stands for 10, l stands for 50 and c stands for 100.

More information about Roman Bumpers can be found at Wikipedia.

<https://web.stanford.edu/class/archive/cs/cs143/cs143.1112/materials/handouts/WA2-solutions.pdf>

**Assignment 4 [Total Marks = 30]**

1. [30] Convert the following CFGs to CNF form

a.  $S \rightarrow ASB$

$A \rightarrow aAS \mid a \mid \varepsilon$

$B \rightarrow SbS \mid A \mid bb$

b.  $S \rightarrow aTXb$

$T \rightarrow XTS \mid \varepsilon$

$X \rightarrow a \mid b$

<https://web.njit.edu/~marvin/cs341/hw/hw06.pdf>

c.  $S \rightarrow aAA$

$A \rightarrow aS \mid bS \mid a$

<http://suraj.lums.edu.pk/~cs311w07/> HW5